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SINCLAIR PROJECTS

FROM THE EDITOR

WELCOME to the fifth issue of *Sinclair Projects*. Despite some early teething troubles, our regular bi-monthly editions are proving increasingly popular with owners of Sinclair machines who wish to do more than play games. We are looking constantly at the service we provide and this month we have made two alterations which should help to make *Sinclair Projects* even better reading.

The first is the inclusion of a Shopping List feature. Many readers have written asking where particular components can be bought and in this regular section we will provide names and addresses of suppliers.

We have also decided to change the symbols we use in the components diagrams from British to international standard. We decided originally to use the British symbols because we understood them to be used in most schools and on examination papers. We have discovered since from the many letters and telephone calls that that is not the case. The readers queried also why we were continuing to use symbols which were not understood outside Britain, unlike the international symbols which are used everywhere else.

In this month's issue we have again been able to include six good projects which we think will be of interest to all Sinclair owners.

Our main feature, which begins on the middle pages, is a device which allows you to use a Spectrum to increase the security of your home. As the author, Corin Howitt, says, burglary is a crime which is increasing but the cost of installing an effective alarm system is such that many people do not think it worthwhile. By taking advantage of the facilities of the Spectrum the cost can be reduced.

The other major feature is a little vehicle which can be controlled by the ZX-81. Our consultant editor, David Buckley, has christened it the Prowler but it has nothing to do with our first project. The little device is an adapted model tank which receives its instructions from the computer.

Howitt has provided a second feature for adding to the Spectrum. It is a real-time clock, long a part of large mainframe computers but rarely found on micros.

Following the building of the graphics generator from our first edition, Tony Noel has supplied toolkit software to help write and store a new character set using the generator. The programs are simple to follow but greatly increase the graphics capabilities of the ZX-81.

Editor Nigel Clark **Consultant editor** Dave Buckley **Production editor** Harold Mayes MBE **News writer** Stephen Adams **Design** Elaine Bishop **Editorial director** John Sterlicchi **Advertisement manager** John Ross **Advertisement Executive** Annette Burrows **Editorial assistant** Margaret Hawkins **Managing director** Terry Cartwright **Chairman** Richard Hease.

Sinclair Projects is published bi-monthly by ECC Publications Ltd. It is in no way connected with Sinclair Research Ltd.

Telephone, all departments: 01-359 7481. If you would like to contribute to any of the *Sinclair User* group of publications please send programs, articles or ideas for hardware projects to Sinclair User and Projects, ECC Publications, 30-31 Islington Green, London N1 8BJ. We pay £50 per 1,000 words for each article used.

 ISSN 0264/0449. Printed and typeset by Cradley Print PLC, Warley, W. Midlands. Distributed by Spotlight Magazine Distribution Ltd, 1 Benwell Road, Holloway, London N7. 01-607 6411.

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Notes on a few of the above applications are included in the manual.

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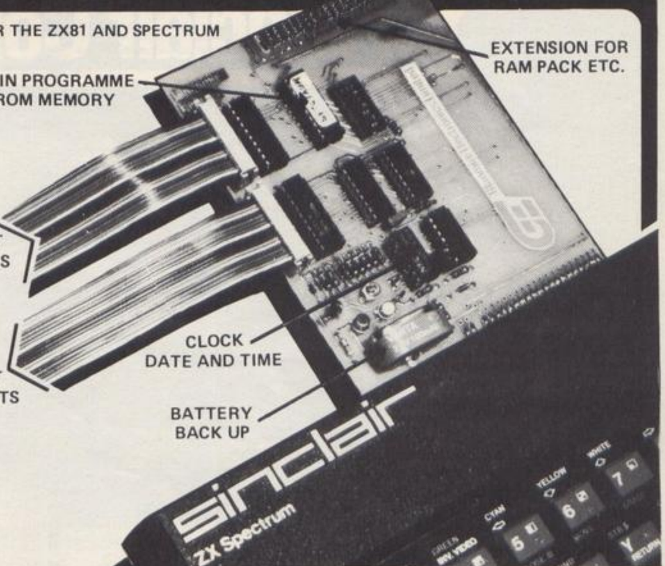

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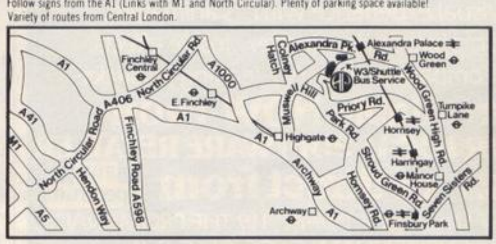

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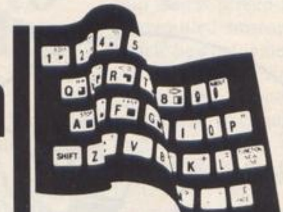

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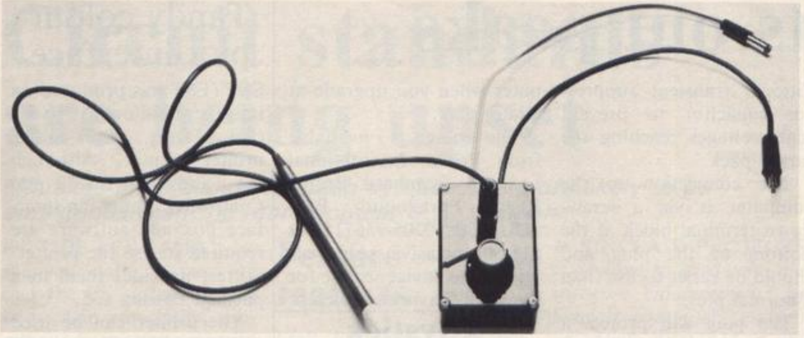
NEWS



Light work of input

THE SPECTRUM Lightpen by dK'tronics is a kit consisting of a tape, light pen with a 3.5mm. plug on the end and a black plastic box. First you run the tape into the Spectrum; the 48K side unfortunately has the 16K version on it and vice versa so if you get out of memory, pull out the plug and start again on the opposite side of the tape. The program loads a Basic instruction program which then loads a machine code program above RAMTOP. All goes well to that point. The instructions on the screen then warn you to plug the light pen via the control box into the computer. The power lead must be diverted through the box when you power-up the computer but the light pen must be disconnected while LOADing or SAVEing. The list of instructions is vast and all letter-coded.

dK'tronics light pen costs £21.20 and is available from Unit 2, Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AX. Tel: 0709-236350.

Plastic cover to reduce wobble

AUDIO COMPUTERS supplies an anti-wobble device for RAM packs. It consists of a plastic shape which is fitted over the edge connector. When the RAM pack is inserted into the back of the ZX-81, two tongues are forced between the edge connector and the case. Two other plastic feet slip underneath the RAM pack. The cost of the anti-wobble device is 50 pence and at first it looks good value but tried on the 16K Sinclair and other RAM packs it has been discovered that using the keyboard vigorously makes the RAM pack 'wiggle' its way out of the expansion port and fall off. That is disadvantageous both to computer and RAM pack.

On its own RAM packs it also has two double-sided sticky pads stuck above the edge connector to hold the RAM pack on to the ZX-81.

Tried with the ZX-81 without the anti-wobbler, the problem was solved, so be advised that a pack of sticky fixers will work wonders; they cost about the same as the device but they fix 20 ZX-81s. Audio Computers is at 87 Bournemouth Park Road, Southend-on-Sea, Essex, SS5 2JJ Tel: 0702-613081.

Binary numbering aid

A VERY USEFUL slide rule-type device is available from ROIS Harder in Canada. It is a binary numbering aid and consists of 16 paper slides in a long piece of card. By pulling up and down the slides one can set various bits in a byte or address and read them in binary, octal, hex or decimal. It is very useful for working-out addresses, decoding ICs or just computer workings in schools. The cost of the Computer Numbering Aid is $6.95 which is high but it falls to $3.50 for quantities of 25 or more. Contact ROIS Harder, 995 Shakespeare Avenue, Nvan, B.C., V7K 1E7, Canada. Tel: 604-980-4167 for more details.

Machine code aid

ROM V is the latest in a salvo of solid state software as the Americans call it — EPROMs — from Eprom Services. It contains a disassembler in a 2K EPROM for the ZX-81. It requires an EPROM board to fit it into but any one will do so long as it allows the EPROM to reside between 8K and 10K.

On RAND USER 10000, it displays a menu of the six commands. All the commands have a description of its use and the letter to use for that command. It can disassemble from any address, including that of its own ROM, print-out or COPY the disassembled program — the printout goes on past a full screen — or jump back to the start of disassembly.

Pressing any key brings up a new screen full of disassembled mnemonics with their hex equivalent and address on each line. All information is put in as hex numbers; decimal is not accepted. Erasing in case of an error is by the use of RUBOUT as in Basic; the cursor keys do not work.

It provides a very useful facility in ROM which is a good aid when faulting or checking a program. It uses no memory apart from the screen and therefore can be used on a 1K machine or a 16K version; being EPROM it is also crash-proof.

A break or Q key can be used to return to Basic at any time. Eprom Services is at 3 Wedgewood Drive, Leeds LS8 1EF. Tel: 0532-667183. The ROM V costs £10.

NEWS

Filter cuts out peaks

THE PLUG-IN mains plug with a difference contains an interference filter as well. The plug is in white plastic and is about 4½in. high and 2in. wide. The fuse in the plug is rated at 3.15 amps and is of the small glass type usually found in radios and TVs, about 1in. long. That should not be replaced with a fuse of a high rating as it would damage the filter inside the plug.

The filter is made up of a ferrite ring wound with two coils, one in the live lead, the other in the neutral. Earth connection is provided but not usually used on Sinclair and other computer game power supplies. The filter is encased in a plastic block and has an additional transient suppressor capacitor to prevent high voltages reaching the power pack.

The connection to the computer is via a screw-down terminal block at the bottom of the plug and should be easier to use than a normal plug.

The plug will protect a computer against high voltages due to motors and other equipment being switched on near them. It will also filter-out any radio interference generated by refrigerators and TVs coming through the mains. It should be ideal for those experiencing unexplained white-outs due to mains interference but not voltage drops and can easily be transferred to another computer when you upgrade at a later date.

The plug is available from Power International Ltd, 2A Isambard Brunel Road, Portsmouth PO1 2DU, Tel: 0705-756715, at £15.50 inclusive. Also offered is an advice service for users still having problems.

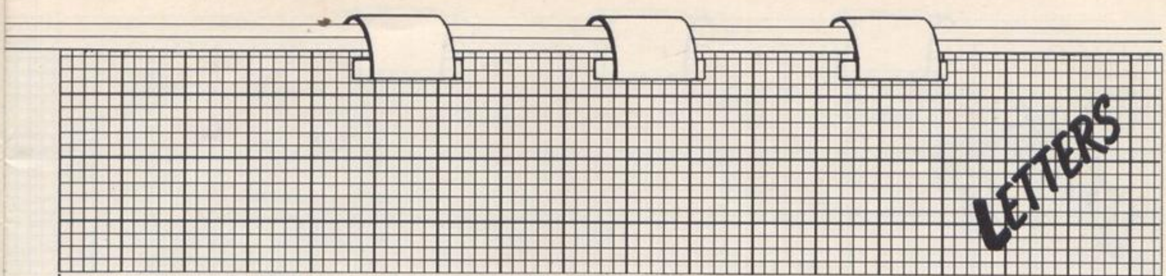
Joystick conversion

KEMPSTON Microelectronics has produced a conversion tape for six of the most popular games which allows you to convert the game for use with its joysticks. It has also included a machine code version of COPY in the latest release of software for the printer interface, called by a USR command.

Tandy colour plot interface

SOFTEST has produced an interface to allow you to use the Tandy four-colour printer plotter. Although the Tandy has RS232 and Centronics inputs, an interface box and software are required to use the printer. Softest provides them in a package costing £35.

The printer can be used to LIST programs from the Spectrum using a machine code routine and the three-part program also allows you to draw graphs and print characters in a 40- or 80-column width. Plain paper is used 4in. wide and the four-colour ballpoints in the unit are black, red, blue and green. For more details contact Softest, 10 Richmond Lane, Romsey, Hampshire.



Circuit standards are being upset

Mistakes arise because British symbols are more likely to be ambiguous than the more popular U.S. symbols.

IN THE APRIL/MAY issue you state on page 45 that the BS system should be used in any design submitted. As the vast majority of the ICs in use are of U.S. origin and are catalogued using U.S. symbols which are, once learned, simple and unambiguous in use, one did not have to look far to find typical examples of errors.

Pages 24–25 — the blocks marked $\frac{1}{4}$74LS02. Reference to the maker's literature shows that they were NOR gates without the one.

In U.S. symbols no such error would be likely.

Page 30 — the $\frac{1}{4}\times$7400. Reference shows that it is a NAND gate printed incorrectly.

Page 43 — $\frac{1}{4}$74LS14 is shown as an inverter, not gate. As it is a Schmitt, that should have been made clear. The U.S. symbolism does that.

In addition to your insistence on BS, you ask for items to be described, not referrred to as IC . . ., you disregard your rules i.e., Tr_1 and TR_2 which are not even mentioned in the text. Also, in the PCB layout you use IC3, IC2 and the like. As they are not referred to either in text or circuit diagram one is at a loss to know what is intended. The PCB tracks and breaks are not shown, so really this diagram is useless.

B D Berman
Burton-on-Trent.

Feature requests

FOR FUTURE issues two projects would interest me — one to utilise some or all of the 8K space from 8192–16383. I have heard that it is possible to use that area as temporary storage for programs or for pseudo ROM. The other, a project to utilise some or all of the space above 32767, either as program storage area or, if possible, as extension for Basic programs.

James Anderson,
Edinburgh.

CAM is unlikely

I SEE in the April/May issue that you have a CAD article. Can you do Computer Integrated Manufacture or CAM? By recent trends, optical optronics light switch gear, instead of printed copper circuitry and chips, has reached the market as optical computers.

At Sussex University a power station using time particles in some way is being designed. Years ago Tachyons were discovered.

Could they use those particles in control systems like that of optical computer systems and optical control gear?

R Donergton
St Albans, Herts.

● SINCLAIR PROJECTS *is devoted to hardware and software enhancements of Sinclair computers and so an article on CAM is unlikely, at least with the present Sinclair range of computers.*

Although optical devices have been made and interconnected, optical computers will not be feasible, let alone on the market, before at least 1990. As to your Tachyons, they are as yet a frivolous, hypothetical, faster-than-light particle.

Room for improvement

I AM WRITING to congratulate you on *Sinclair Projects.* Each issue so far has contained worthwhile projects. Regrettably there are some criticisms to be made and I hope you will regard them as being constructive.

First, for the RS232 interface for the Spectrum in the April/May edition. R S Components is quoted as a supplier for parts. The company does not deal with individual members of the public and not everybody has access to it on a regular business or school order. Perhaps you could try to attract advertising from firms such as Maplin, Watford, Technomatic, Ambit and so on; I feel that would be more useful.

Like other correspondents, I feel compelled to comment on the standard of technical drawing. Labels should be either inside or outside component boxes but not straddling wiring or sides of boxes. Please try to be consistent when referring to ICs — not 74124 in one diagram and 74LS124 in the next; and not 12474LS, please.

What is wrong with labelling something 'IC5' and having component tables elsewhere? It certainly saves clutter on the diagram. When drawing Vero layouts try to be accurate and label the external connections to the board; the RTTY interface February/March left far too much to the constructor's knowledge of TTL and his skill at guesswork.

Please try to draw capacitors, resistors and pots all the same size. Seriously, the clarity, or perhaps understandability of a circuit and its accompanying description can often mean the difference between success and failure when constructing a project.

Finally, a plea to use American standard logic symbols. I know we should buy British but the American equivalents are infinitely more widespread. Obviously I cannot speak for other educational establishments but at Wolverhampton Polytechnic we are taught American symbols; they are explained in all our recommended texts. Why does *Sinclair Projects* have to be different?

Tim Scrimshaw
Birmingham.

● *Thank you for your comments. You will see that from this issue we have de-*

LETTERS

Continued from page 11
cided to use international standard symbols which should reduce errors in diagrams.

Joystick sticking

I ENJOYED reading issue one of *Sinclair Projects*. I embarked on making the joystick controller for my Spectrum but I have been having difficulty trying to find a 28-way edge connector. Could you tell me where I can obtain one and how much it costs. Also please could you send me some more information on where you solder the wires into the back of the edge connector, as it was not presented very clearly.

Simon Smith
Plymouth, Devon.

● *Figure five shows the back of the edge connector with the places where connections are to be made and the photograph on page 16 shows the connector with attached wires by the side of the box. See the reply to B Walters in the June/July issue for update to the joystick project. The Shopping Page gives suppliers of the edge connector.*

Search for missing link

I WISH to build a Latch Card as explained on pages 20 to 24 of your December/January issue. I have been able to order all the necessary parts from Maplin Electronics Supplies Ltd except integrated circuit part 74LS133, which is not listed in its catalogue. Can you inform me from where I can obtain one?

Peter Litten (aged 13)
Pontefract,
W. Yorkshire.

● *See the Shopping Page for the 74LS133 and see the reply to Martin Hunt in the June/July issue for updates to the project.*

Capacitor area

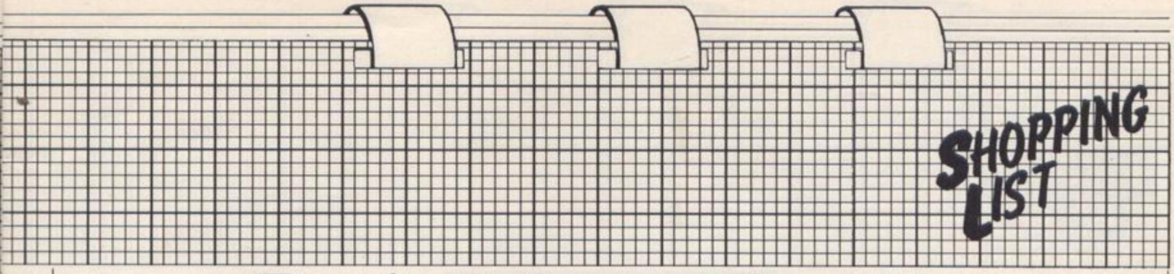
I AM TRYING to build the Eprom Blower featured in issue two and I am having a little difficulty. Finding the drawings confusing I decided to re-design the boards following the circuit diagram. I noticed the 8μF capacitor and the two 5K6 resistors were not mentioned on the parts list but that the 0.1μF capacitor on the board which holds the main circuitry was. That was because it is not drawn in on the circuit diagram. Could you please tell me where it goes?

Another slight problem was what do I do with the A4 address line from the ZX-81? A1-3 and A5-7 are perfectly clear but A4 is not mentioned. Do I leave that alone or should I connect it to somewhere?

While I am writing, may I congratulate you on a really useful magazine. I have found the articles and projects interesting and helpful.

Jon Slack
Skegness, Lincs.

● *The* 0μF *capacitor is connected between 0V and 5V. One end goes to pin 24 of the EPROM socket and the other to pin 7 of the 74LS00. Address line A4 is not connected. See also February/March pages 47 and 48 for updates to the project.*



Project buyers' guide

HERE IS a list of suppliers for difficult-to-obtain items which have been used in projects.

Hinged PC supports for Project Prowler are available only from **MS Components** in packs of 10 pairs. **Innovonics** can supply the two pairs required for the project for 80 pence inclusive.

74LS133 IC as used in the Latch Card project.

MS Components Ltd
Ambit International
Watford Electronics

MM58174 real-time clock IC.

Cricklewood Electronics
Watford Electronics

PCB mounting 3.5mm. jack sockets as used in the Central Heating Controller project.

MS Components Ltd

16-way ribbon cable
16-pin DIL IDC headers

Fuselodge Ltd

Edge connectors 23-way for ZX-81 and 28-way for Spectrum.

Innovonics

Extender cards for fitting to rear of edge connector to allow stacking add-ons.

23-way for ZX-81 — ZXTONGUE
28-way for Spectrum — SPECTONGUE

Innovonics

MS Components Ltd, Zephyr House, Waring Street, West Norwood, London SE27. Tel: 01-670 4466.
Ambit International, 200 North Service Road, Brentwood, Essex. Tel: 0277-230909.
Watford Electronics, 33–34 Cardiff Road, Watford, Herts. Tel: 0923-40588.
Innovonics, 147 Upland Road, East Dulwich, London SE22.
Cricklewood Electronics Ltd, 40 Cricklewood Broadway, London NW2 3ET. Tel: 01-452 0161.
Fuselodge Ltd, 267 Acton Lane, Chiswick, London W4 5DD. Tel: 01-994 6275.

UPDATE

Errors and mishaps

Updates, June/July issue. Machine code, line 1050 at end should read
. . . . . (Z$(2) > "9") + 48).
Decoder 40151 should read 49151.

Graph plotter, page 16. Lines 1390 and 1400 should read
1390 PRINT AT 20,30–t;a;"PI"
1400 IF d=0 THEN PRINT AT 20,3;"0".

Sound generator. Figure one: the top IC4d should read IC4c; the resistor connected to pin 23 should be labelled 10K.

Table one R6 should read 5-bit period control. Page 26, line 5, should read the OUT 191,a command.

Figure five: The resistor by IC1 pin 1 should be labelled 1K. The numbers on the left-hand side of the diagram should have been titled Edge connector bottom row pins.

Decoding, page 32: The table in figure one should read:

State of inputs for output to go low			Output
A_x	A_y	A_z	$\overline{y}$
0	0	0	0
0	0	1	1
0	1	0	3
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

Table one: The line Pinout PD, S5485 is not relevant. The table beside table two belongs to figure eight.

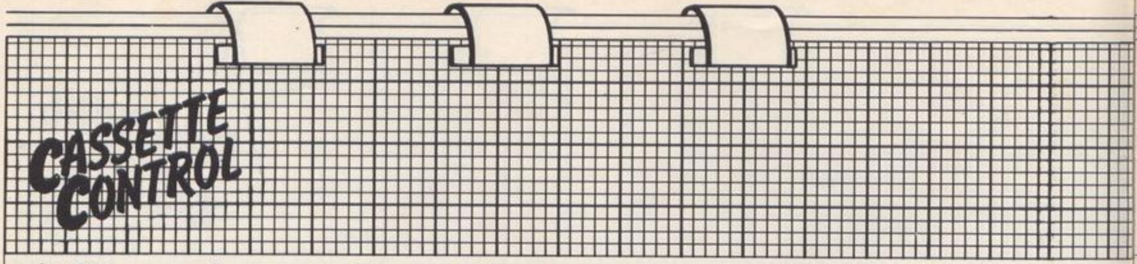
Watchdog, page 40, col. 3, line 14: 'supplying' should read 'controlling'. Figure three: The text in the centre should read: ALL GATES ¼4011.

Sinclair Projects, *April/May 1983.* **Central Heating,** page 26, column three:
LD C,82; DELAY COUNT should read LD C,02; DELAY COUNT.

Page 27, column one, Table 1 should have read:

Address		RD cycle	WR cycle
Hex	Dec		
2000	8192	CH1 ADC	DAC 1
2001	8193	CH2 ADC	DAC 1
2002	8194	CH3 ADC	DAC 1
2003	8195	CH4 ADC	DAC 1
2004	8196	Read ADC	DAC 2
2005	8197	Read ADC	DAC 2
2006	8198	Read ADC	DAC 2
2007	8199	Read ADC	DAC 2

Also page 46



Allowing the Spectrum to control the cassette recorder

Almost all recorders have a means of stopping and starting the tape in addition to the normal keys. Howard Neale shows how to build a motor control system.

FOR THOSE with a Not the BBC computer—alias the Spectrum—who would like a feature which the BBC machine has, here is a simple and inexpensive cassette recorder controller.

Having built an eight-line in/eight-line out interface featured originally in *Sinclair Projects,* I became interested in the 74 series chips and decided to learn more about some of them. At the same time I had written two educational programs which with a 16K Spectrum required the MERGEing of extra data to make them usable by several children over a period. So the idea of the tape control emerged.

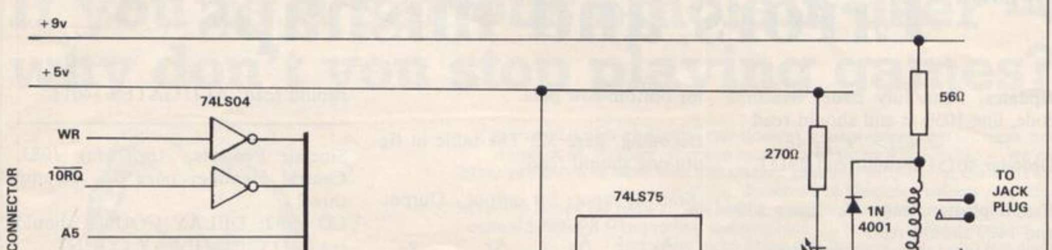
Nearly all cassette recorders have a means of controlling the motor in addition to the piano-key controls. That is either a connection via a DIN plug or a jack plug socket. On many recorders there are three jack plug sockets, usually marked MIC, EAR and REM. It is the last of them which is of interest as the REM socket, when connected to a switch via a plug and lead, will switch the motor on and off provided the PLAY key is depressed. In the interface that switch is a sub-miniature 5V PCB relay.

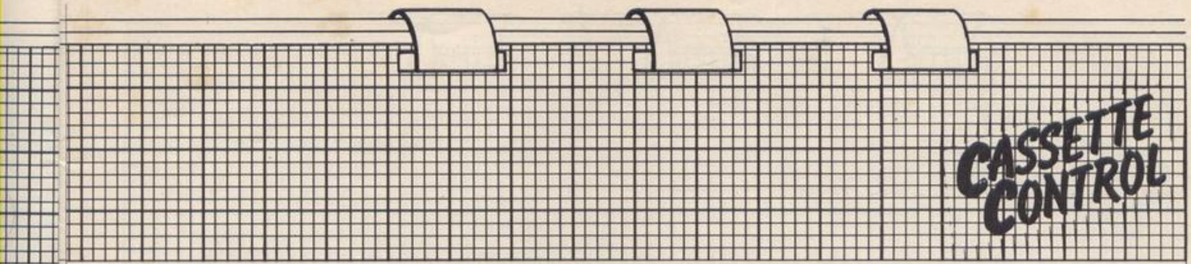
Before progressing to the design of the interface, I would like to retrace the working of some of the digital electronics which will be the building blocks of the device.

Digital electronics is comparatively simple at a basic level. We need to consider only if there is a pulse of electricity, usually 5V and called logic level 1, or, if there is no pulse, called logic level 0V. The most important chip in a computer is its CPU, a very complicated device, and although we do not need to understand it fully we must know a little about it.

The Z-80A chip in the Spectrum is sending and receiving signals in the form of those pulses of electricity. Address signals run along 16 paths or lines. They are numbered A0 to A15. Signals along those lines prepare the memory locations to send or receive data. They are also used to select input/output devices. The data is in portions of eight pulses travelling along eight lines called D0 to D7. The

Figure 1: Circuit diagram.





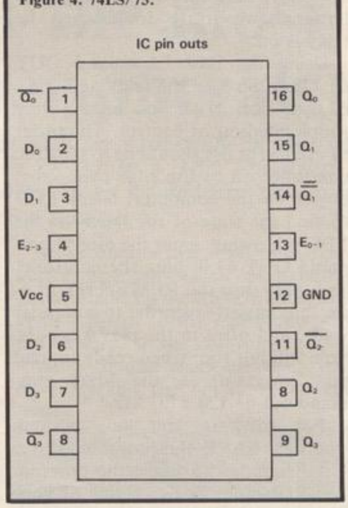
data pulses represent information such as your Basic program converted into binary or numbers between 0 and 255. The data lines are also used to control the device selected by the address lines for control work.

Some other lines emerge from the Z-80A chip which are used to specify jobs to be done, for example $\overline{WR}$ is active and at logic level 0 when data is written or sent out, $\overline{IORQ}$ is active and at logic level 0 when input/output work is to be done.

You will notice in the manual, page 159, that the OUT statement requires an address and a value between 0 and 255. The address sends a logic level 1 signal on the A lines which make up that number in binary, i.e., 31 makes lines A0 to A4 logic 1. The value number does the same for the D lines.

Smaller digital devices such as the 74 series chips also do certain things with those pulses. We need to look at only three of the chips for this interface. An inverter takes a logic 1 in and changes it to a logic 0 and vice versa. An AND gate has a number of lines in and one line out. If, and only if, all the in lines are at logic 1, the output line will be at logic 1. A NAND gate is an AND gate with an inverted output so if all the inputs are

Figure 4: 74LS/75.



at logic 1, the output line will be at logic 0.

A LATCH is a device which can be turned on by a pulse into its ENABLE pin and which will then take in and hold a data pulse. In other words, when enabled, the chip will receive a data pulse at logic 1 and its output will remain at logic 1 until the next enable pulse and data pulse arrive.

At the computer end I chose to use as few lines as possible. The address lines A0 to A4 must be used, as they control other functions. For instance, if A2 goes to logic 0, the Spectrum thinks the printer is connected. In addition, I decided to use A5. As the work is only in the output mode, the lines $\overline{WR}$ and $\overline{IORQ}$ have to be used. Any data line can be used but I decided to use D7, so any value equal to or greater than 128 will turn on and any less than that will turn off the latch. In addition, connections are required to 5V and 0V for powering the circuit.

Incidentally, only 22 edge connector positions are required so the ZX-81 connectors can be used; they are generally cheaper than Spectrum connectors.

Only three chips are required. They are 74LS30—eight-input NAND; 74LS04—hex inverter; 74LS/75-four-bit latch. Other hardware required will be a BC-108 transistor or equivalent, one 1K, one 270ohm and one 56ohm resistor, one LED and one diode, 1N 4001 or similar.

When the Basic command OUT 63,128 is used a number of things happen. The address lines A0, A1, A2, A3, A4 and A5 go to logic 1 (5V) as shown by the binary form of the number 63—00111111—the $\overline{WR}$ and $\overline{IORQ}$ lines go to logic 0—OV.

To switch the eight-input NAND, all eight lines must be at the same logic level. The $\overline{WR}$ and $\overline{IORQ}$ lines are put into two sections of the hex inverter, thus making the logic level on those lines up to 1s.

All eight 1s into the NAND gate will produce an output of logic 0 which needs to be inverted into a logic 1 to be fed into the ENABLE pin of the 74LS/75 latch. So it is that the latch is selected by the address line number.

With the latch then enabled, the D7 line must become logic 1, which requires the value of 128 as the second argument in the command. A word about the 74LS/75 chip. I find it very useful. It is only a four-bit latch and you have eight data lines, so often

Figure 2: 74LS04.

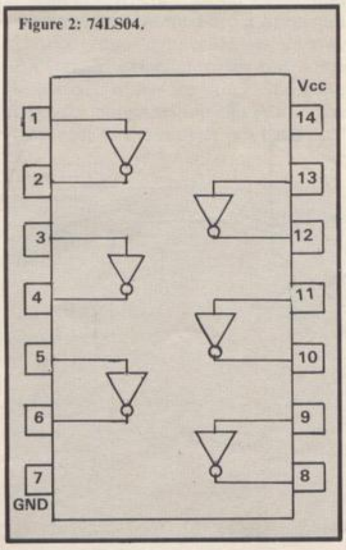
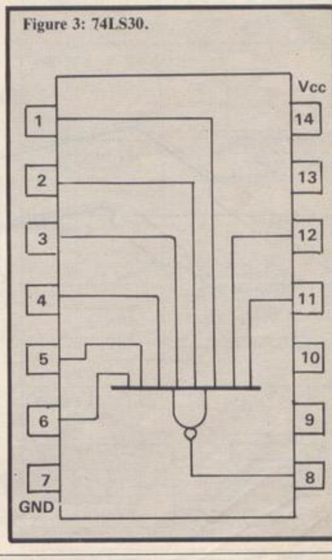


Figure 3: 74LS30.



CASSETTE CONTROL

two chips are required but the '75 is only about one-quarter the price of an eight-bit latch like the '373 and has other features. The lines are enabled in pairs, so it is very controllable; also for every input line there are two output lines with one line inverted.

If we trace each output line from the latch, it will be noticed that the inverted line is used to sink—take in—current through a LED and series 270ohm resistor. The LED acts as an indicator to show when the relay is on. The latch output holding logic level 1—5V—is fed through a 1K resistor to the base of a BC-108 transistor. That will 'switch' the transistor on, allowing current to flow through the relay into the collector of the BC-108.

A 56ohm resistor in series with the relay coil will reduce the power drain on the Spectrum but may be ignored or varied to suit the relay. Do not forget the diode across the relay coil to prevent damage to the transistor when the current is turned off. Finally, the lead to the jack plug is wired to the switching terminals of the relay; take care to join it to the terminals which are closed when the relay is on.

Using the Basic command OUT 63,128 to turn on the relay and OUT 63,0 to turn it off you have a very simple method of control. The order of events for use should be to plug the controller on to the edge connector; power up the computer; check LED to find the state of the latch—if the LED is glowing, enter the direct command OUT 63,0; plug the controller jack plug into the REM socket, connect the cassette recorder to computer leads, and press in the play key—the tape will not run; when ready to load your program, use the direct command out 63,128 : LOAD " "

For software you have written yourself, SAVE the program with a LINE number to make the program self-RUNning. The first line of your program can then be 10 OUT 63,0. If further cassette work is needed, enter a line such as OUT 63,128 : MERGE " " followed by xxxx +1 OUT 63,0 : RUN 20 (or GOTO 20).

Another useful feature is to combine the use of the controller with the ability of the Spectrum to load another screenful of picture—for this, xxxx OUT 63,128 : LOAD " " SCREEN followed by xxxx +1 OUT 63,0 : GOTO xx.

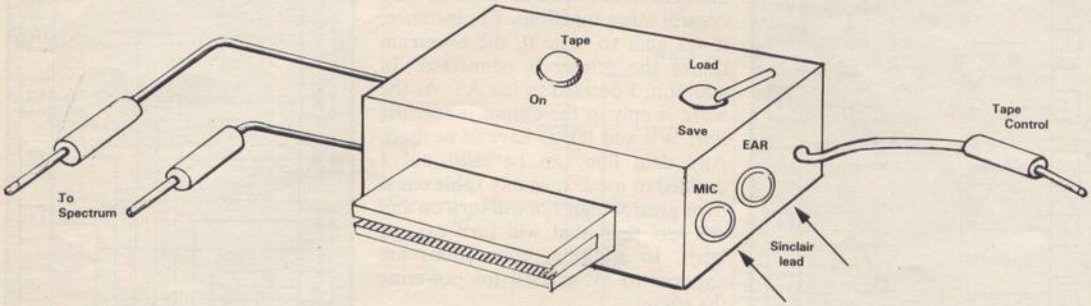
Remember always to put the OUT command first; if you do not do so the computer will wait for the program to load before moving on to the next command, but the program cannot load as the recorder is not turned on.

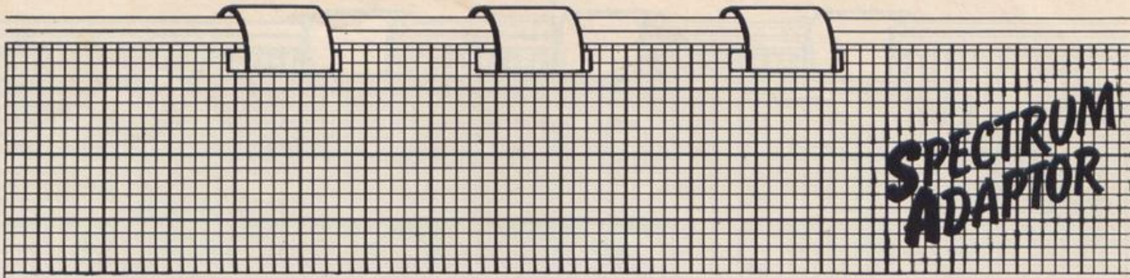
The controller can be built into a box which could also contain a switch to cut out the EAR line from the computer to the cassette recorder. As many people will know, that is a useful device to cut out the feedback when SAVEing and it means you do not have to pull out the jack plug.

As an addition, another relay, transistor and LED would allow one to use another part of the latch to control the function as well.

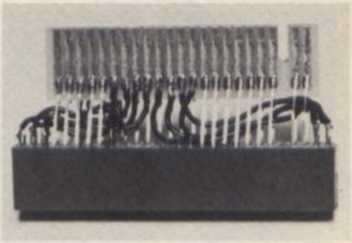
Finally, the controller could also be used with the ZX-81 with a short machine code routine to call the OUTput.

Figure 5: Completed unit.





How to get the most from old peripherals



This easily-constructed project will be especially useful to those who have moved from a ZX-81 to a 16K Spectrum. David Buckley shows you how to make an adaptor to allow you to use ZX-81 add-ons with a Spectrum.

THOSE WHO STARTED with a ZX-81 and then upgraded to a Spectrum were no doubt left with some peripherals—I/O boards, sound boards and the like—which you wished could be used on the Spectrum.

This project, when plugged into the Spectrum, changes the Spectrum edge connector to a ZX-81 connector and so ZX-81 add-ons may be plugged into the Spectrum.

If the add-on is memory-mapped it will work only if its address does not clash with that of Spectrum memory. That means that most I/O-mapped add-ons will work and memory-mapped add-ons addressed above 32K will work with the 16K Spectrum. I use it to enable me to use the Latch Card of issue one on the Spectrum.

The construction is very easy and the only parts needed are a Spectrum 28-way edge connector, a 23-way ZXTongue extender card and some insulated wire—see the Shopping Page for shops selling the parts. The total cost of the project is a little over £3.

Table 1

Signal	Spectrum connector pin
Spare	4a
−5V	20a
+12V	22a
−12V	23a
Spare	28a
$\overline{\text{IORQGE}}$	13b
OV	14b
Video	15b
y	16b
v	17b
u	18b

Mark on the Spectrum edge connector those pins which carry signals not available on the ZX-81. Table one gives a list of them. Those pins will not be wired to the ZXTongue.

After double-checking that you have marked the correct pins, cut them off close to where they emerge from the connector body.

Table 2

Signal	Spectrum pin number	ZX-81 pin number
A_{15}	1a	11b
A_{14}	1b	12b
A_{13}	2a	13b
A_{12}	2b	14b
A^{11}	28b	15b
A_{10}	27a	16b
A_9	27b	17b
A_8	26a	18b
$\overline{\text{BUSRQ}}$	19b	20a
$\overline{\text{RESET}}$	20b	21a
$\overline{\text{BUSAK}}$	26b	18a

Next see table two for those signals which appear in a different location on the Spectrum and ZX-81 connectors. Mark those pins as previously and then, after checking, cut them off about 4mm. from the edge connector body.

The next step is to solder the ZX-Tongue to the top row of pins of the edge connector—see figure one—making sure that there is about 6mm. between the connector body and the rear of the ZXTongue. Also make sure that the slot in the ZXTongue is aligned with the polarising key in the Spectrum connector.

After soldering the top row of pins they should be bent so that the top surface of the ZXTongue is level with the top surface of the connector body—see figure two. The ZX-81 circuit board is higher than that of the Spectrum and unless the ZXTongue is raised, as in figure two, ZX-81 add-ons when fitted on to the extender board will prevent the rear feet of the Spectrum reaching the table.

The lower row of pins should then be bent up to reach the circuit board as in figure three and soldered in place. When bending those pins they should not be bent sideways but must be soldered to the track on the ZXTongue immediately behind them.

When that has been done the remaining tracks on the ZXTongue should be wired to the remaining short pins on the connector. See table two and the edge connector diagrams at the back of the magazine for the positions.

Note that the adaptor does not allow you to use a ZX-81 RAM pack.

Figure 1

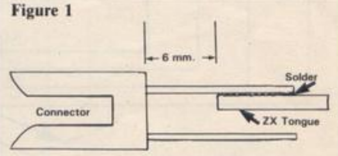


Figure 2

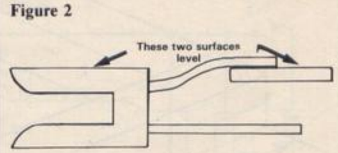
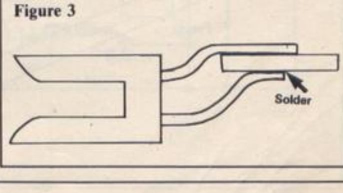
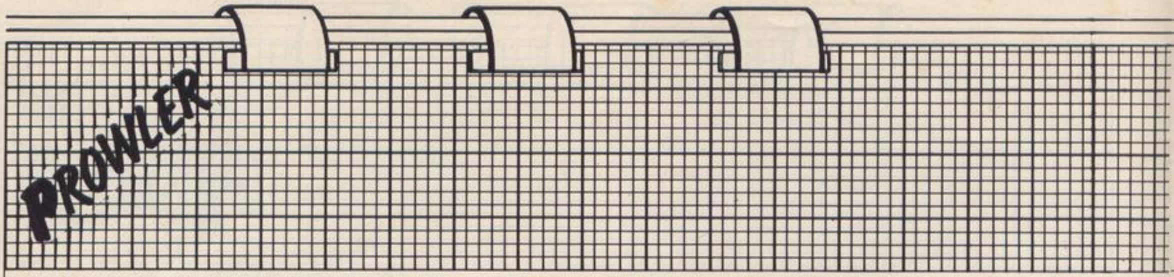


Figure 3





Prowler control adds movement to the ZX-81

Most computer-controlled vehicles produced so far are relatively expensive. David Buckley shows how to reduce that cost and make a simple device which can be expanded.

YOU PROBABLY will have noticed that robots are more and more in the news. Turtles are being introduced into schools and various magazines have published articles or projects on computer-controlled vehicles and arms.

So far the available robotic add-ons have needed either complex software to interface them to a home computer or have been too costly, or too big. The BBC Buggy costs more than £100 and even Zeaker, the latest of the add-ons, costs slightly more than £50.

Projects Prowler in its first stage of development should cost about £20.

Prowler consists of a converted remote-controlled $^1/_{35}$-scale tank kit, with a circuit board holding some electronics to control the motors, lights, horn and later some bump sensors. Other boards can be stacked on top of the main board so that control for other sensors such as optical sensors—eyes—and effectors such as a small gripper can be added. Other possibilities include a sound generator board, speech board and a remote link to the controlling computer.

At present Prowler is controlled by signals down a 16-way ribbon cable umbilical which at the computer end plugs into a standard 8-bit output port such as the Latch Card of issue one.

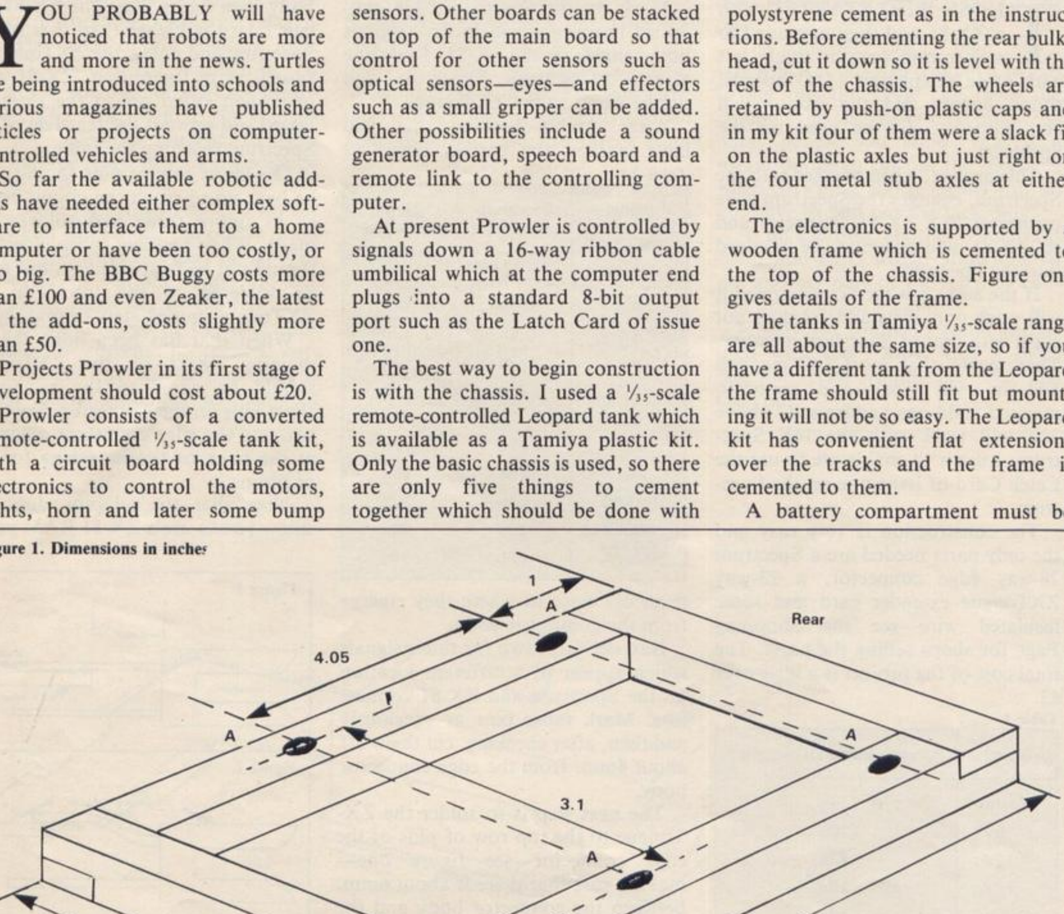
The best way to begin construction is with the chassis. I used a $^1/_{35}$-scale remote-controlled Leopard tank which is available as a Tamiya plastic kit. Only the basic chassis is used, so there are only five things to cement together which should be done with polystyrene cement as in the instructions. Before cementing the rear bulkhead, cut it down so it is level with the rest of the chassis. The wheels are retained by push-on plastic caps and in my kit four of them were a slack fit on the plastic axles but just right on the four metal stub axles at either end.

The electronics is supported by a wooden frame which is cemented to the top of the chassis. Figure one gives details of the frame.

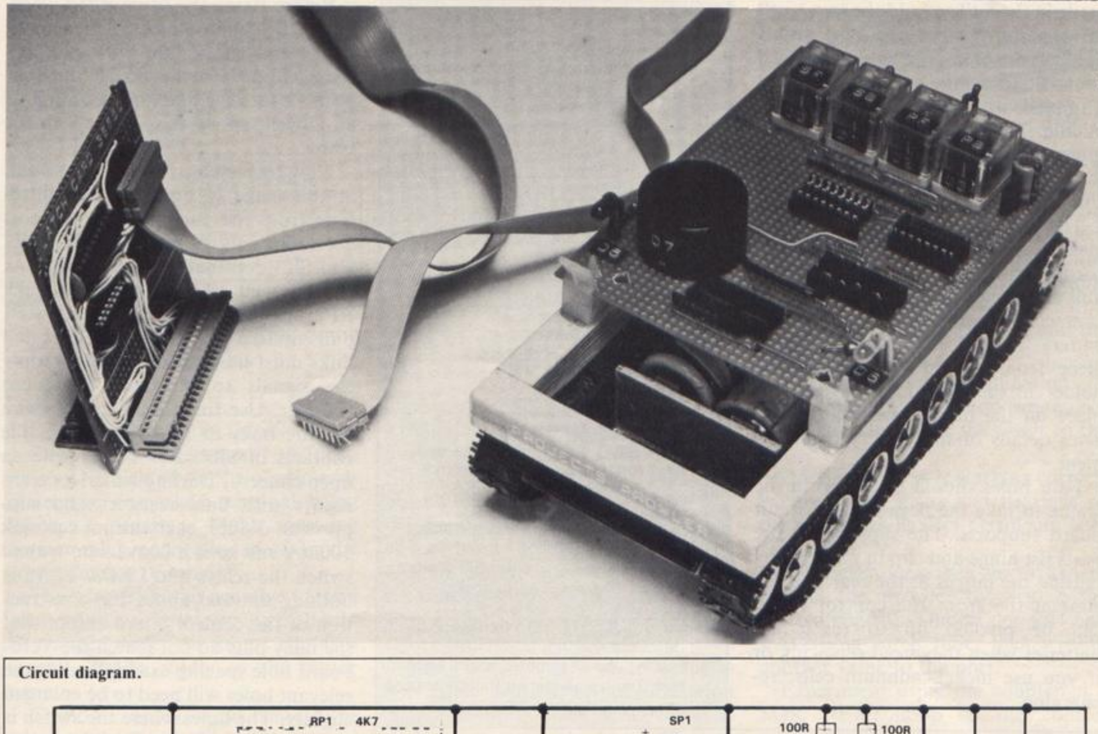
The tanks in Tamiya $^1/_{35}$-scale range are all about the same size, so if you have a different tank from the Leopard the frame should still fit but mounting it will not be so easy. The Leopard kit has convenient flat extensions over the tracks and the frame is cemented to them.

A battery compartment must be

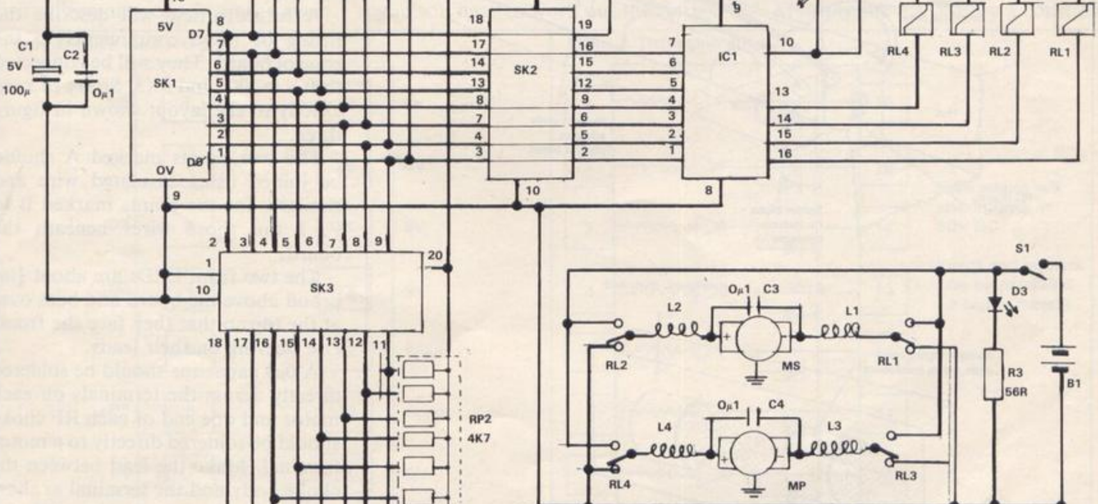
Figure 1. Dimensions in inches



Frame ½in. softwood; holes (A) 4.5mm diameter.



Circuit diagram.



made in the hull to hold the two c-cell drive batteries. For the rear end I used a piece of copper laminate board cut to fit across the hull and cemented it in place after grooving it down the middle. The groove was made with a junior hacksaw, just cutting through the copper to isolate the two battery contacts.

The front of the battery compartment I made from a piece of $\frac{1}{8}$in. hardboard, again cut to fit across the hull and cemented in place. To make contact between the two cells of the battery I used the metal bridging piece from the end of the battery holder in the kit and epoxyed it in place on the hardboard. Figure two gives details of the battery compartment.

Four holes should be drilled in the frame to take the pegs on the circuit board supports. The supports in the parts list hinge and clip in pairs, so by putting the hinges at the rear and the clips at the front the control board can be pivoted up to reach the batteries when they need replacing or if you use nickel-cadmium cells, recharging.

Table 1.

Control value	*Action*
0	Everything off
1	Starboard motor forwards
2	Starboard motor backwards
4	Port motor forwards
8	Port motor backwards
64	Lights on
128	Horn on

COMPONENTS LIST

C1 100μ 5V electrolytic radial
C2, C3, C4 0μ1 disc ceramic
R1, R2 100R $\frac{1}{4}$ watt
R3 56R $\frac{1}{4}$ watt
RP1, RP2 4K7 × 8 [Ambit 48-47000]*
L1, L2, L3, L4 1 amp RF choke [Maplin HW04E]*
IC1 Darlington driver ULN2003 [MS Cpts 10374]
D1 0.2in. red LED
D2 0.2in. green LED
D3 0.1in. orange LED
RL1–RL4 6V single-pole, double-throw relay SPDT [Ambit 46-80000]*
SP1 Self-oscillating piezo sounder [Ambit 43-99300]*
S1 Ultra miniature toggle single-pole, double-throw SPDT
SK1, Socket for IC1 16-pin DIL socket
SK2, SK3 20-pin × 0.3 DIL socket
Veroboard 50 holes × 36 strips
Hinged PC supports 11mm. high 2 pair [MS Cpts 4020]*
Tank kit $\frac{1}{35}$-scale remote control Leopard tank Tamiya plastic kit [hobby shops]

*see Shopping Page

Before fixing the supports in place, make the 4mm. holes in the circuit board and check that with the supports clipped to the board the supports fit into the holes in the frame. If all is well, epoxy the supports to the frame.

Now to the electronics. The circuit at this stage is simple. The control byte from the computer output port enters the control board by SK1. SK2 and SK3 eventually will hold ICs. At the moment SK3 and resistor pack RP2 are unused. Resistor pack RP1 pulls up to 5V all eight data lines and links must be pushed in SK2 to route the signals to IC1 and the piezo sounder. Use fine tinned copper wire for the links so as not to strain the contacts in SK2. IC1 contains seven open collector Darlington driver transistors with base resistors and suppression diodes; each output can sink 500mA and so is a convenient way to switch the relays and LEDs. There is nothing unusual about the construction of the control board except that the relay pins do not match the Veroboard hole spacing exactly and so the relevant holes will need to be enlarged slightly. The holes where the switch is mounted should also be enlarged so that the switch body rests on the Veroboard.

A future article will describe the fitting of more components to the control board. They will be connected to ICs in SK2 and SK3. So try to keep exactly to the layout shown in figure three.

The two points marked A should be joined using insulated wire and similarly for the points marked B to F. I ran those wires beneath the board.

The two front LEDs are about $\frac{5}{8}$in. proud above the board and bent over at the top so that they face the front. Use sleeving on their leads.

A 0μ1 capacitor should be soldered directly across the terminals on each motor and one end of each RF choke should be soldered directly to a motor terminal. Make the lead between the choke body and the terminal as short as practicable—about $\frac{1}{4}$in. will do. The other ends of the chokes are wired to the points MS−, MS+,

Figure 3.

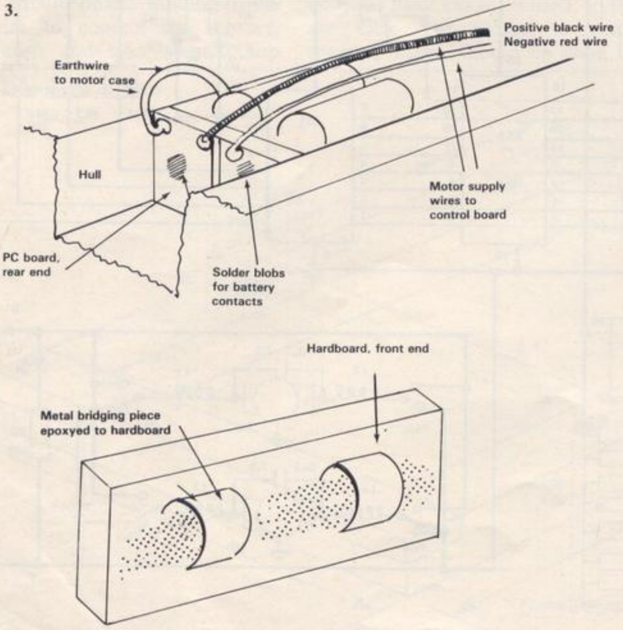
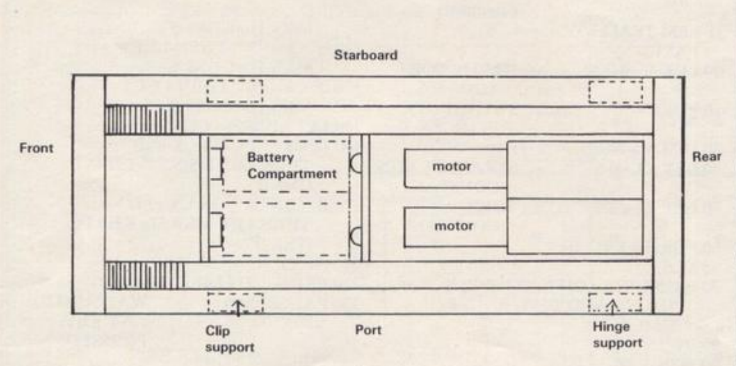


Figure 2. Battery compartment.



MP−, MP+ by using flexible wire.

The positive terminal on each motor is indicated on the plastic end-plate, the unmarked terminal being taken as negative. Make sure the correct relay connection goes to the correct motor terminal.

The wire from the negative battery connection to the motor case should be trapped under the motor clip as it is not easy to solder to the motor cases.

The 3V supply wires should be wired to the Veropins on the control board. I placed a piece of cardboard over the gearboxes to prevent those wires becoming caught in the gears.

After checking everything thoroughly, put in some batteries, switch S1 towards D3, and D3 should light but nothing else should happen.

I mentioned that the Prowler could be run from the Latch Card of issue one but I have altered the wiring of the output socket of the Latch Card. The amended socket is detailed in figure four.

Using a 6ft. length of 16-way ribbon cable with a 16-pin insulation displacement connector, headers at each end connect the Latch Card to SK1 on Prowler.

If you are using other I/O boards you will have to work out the connections to the ribbon cable necessary to suit your board; use an ohmeter to check that you have made the correct connections. Ensure that the Prowler is switched off; LED D3 should be out.

Power-up the computer and you will probably be greeted by the horn sounding. Write a zero to the port and everything should be off. Switch on the Prowler with S1; still nothing should happen. The values in table one should be written to the port with the corresponding action from the Prowler.

To switch any combination of items from table one, add the respective values and write the result to the port.

Once everything is working correctly, grease the gears and bearings of the gearboxes lightly; petroleum jelly will suffice.

A program can then be written to control the Prowler by writing the desired control value to the port and PAUSEing for a time, then writing another value to the port.

Experiment using the counter in a FOR NEXT loop as the control value. Prowler executes various weird kinds of dances depending on the PAUSE time.

Multiply the PAUSE by a constant

Figure 4. Latch Card I/O port.

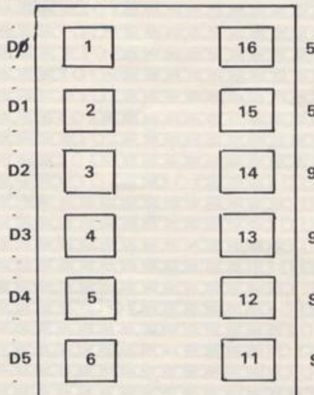
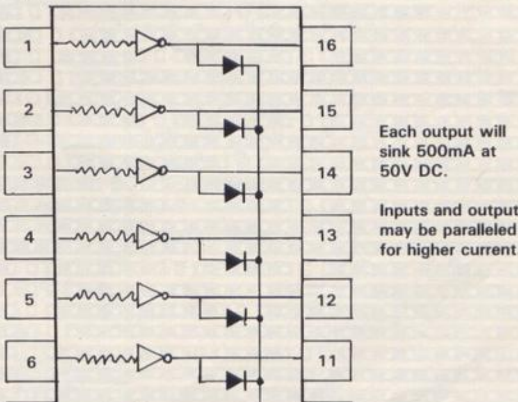


Figure 5. Darlington driver.



PROWLER

so that go forward, PAUSE 5Ø is equivalent to going forward 50mm. Similarly experiment to find the constant for angles to be turned.

Rather than hold the control values as numbers, convert them to characters so that you can build strings. Use one string for control values and one for PAUSE times. That way you can build complex patterns from simple patterns using string addition.

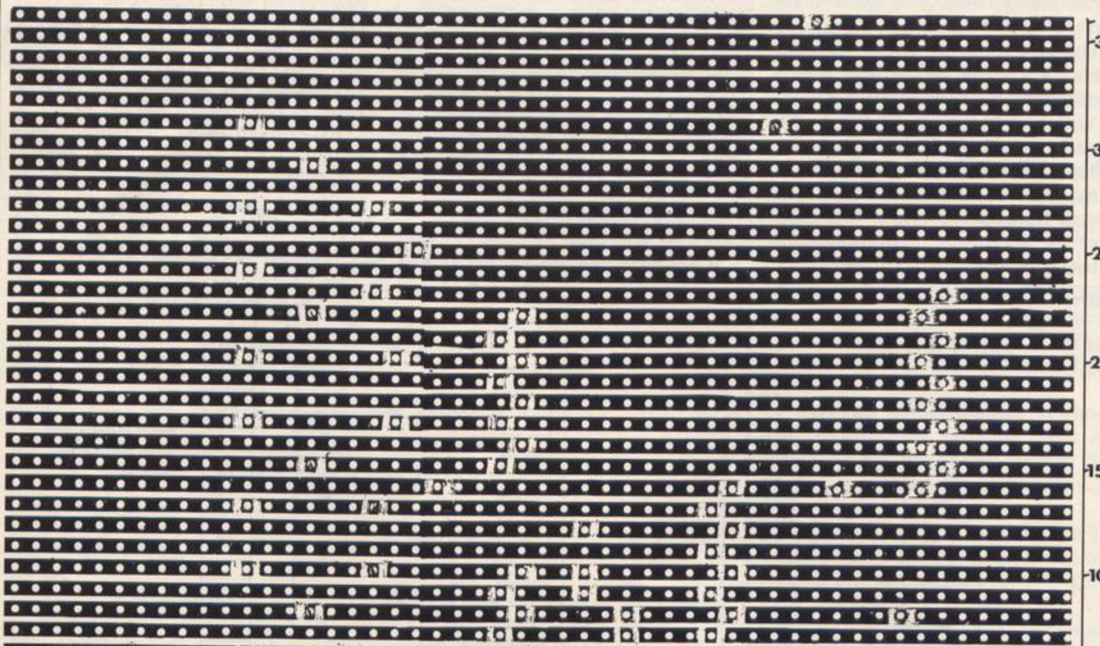
One word of caution on using Prowler; if you keep doing turns on a carpet or other grippy surface, the tracks will come off but on a table top or smooth floor everything is satisfactory.

In the next article we will deal with the fitting of bump sensors so that your Prowler can explore and take evasive action when it encounters an obstacle.

Keyboard Teach Program 1K ZX-81.

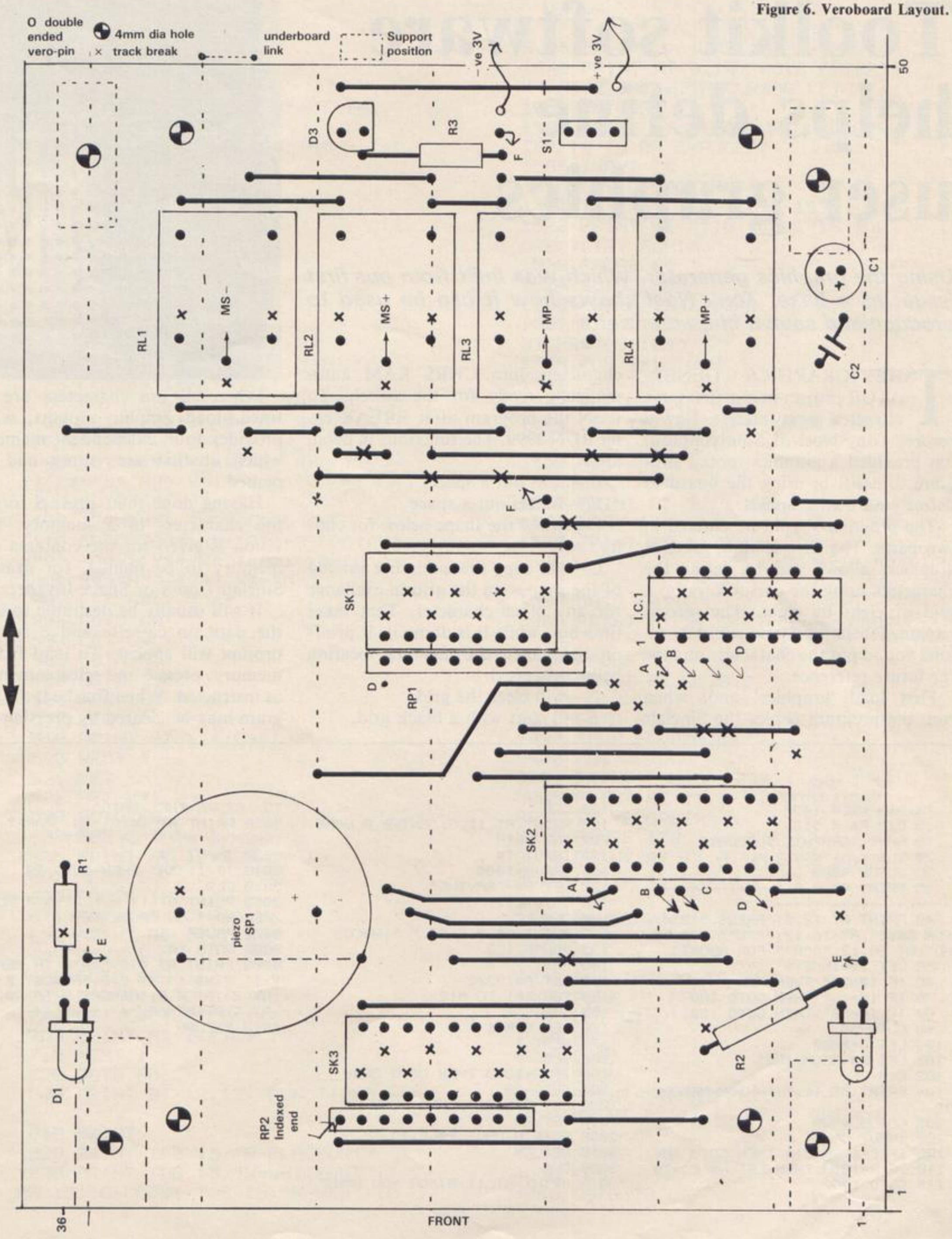
```
                                    Comments
(1 REM TEACH/DOIT)
 5 FAST
10 LET A=36850  ____  36850 IS PORT
                         ADDRESS
20 POKE A,O     ____  SWITCH OFF
                         VEHICLE
30 DIM M$ (10,2)
40 LET K1=0.5   ____  STRAIGHT RUN
                         CONSTANT
50 LET K2=0.5   ____  TURN
                         CONSTANT
60 FOR S=1 TO 10
65 CLS
70 PRINT "TEACH", "STEP"; S,
    "MOVE AND DIST/ANGLE/
    TIME"
80 INPUT C$
90 INPUT D
100 IF C$="F" THEN LET
    M$(S,1)=CHR$ 5
110 IF C$="B" THEN LET
    M$(S,1)=CHR$ 10
120 IF C$="L" THEN LET
    M$(S,1)=CHR$ 9
130 IF C$="R" THEN LET
    M$(S,1)=CHR$ 6
140 IF C$="S" THEN LET
    M$(S,1)=CHR$ 0
150 LET M$(S,2)=CHR$ D
160 IF C$="F" OR C$="B"
    THEN LET M$(S,2)=CHR$
    (DxK1)
170 IF C$="R" OR C$="L"
    THEN LET M$(S,2)=CHR$
    (DxK2)
210 NEXT S
220 PRINT "TO DO IT PRESS D"
230 PAUSE50000          WAIT UNTIL
                        ANY KEY
                        PRESSED
240 FOR S=1 TO 10
250 POKE A,CODE M$(S,1)
260 PAUSE CODE M$(S,2)
270 NEXT S
280 POKE A,O
290 GOTO 230
```

Figure 8. Back of Veroboard.



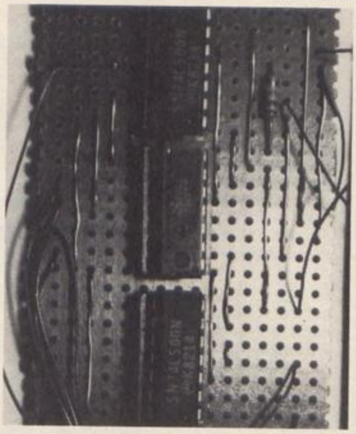
PROWLER

Figure 6. Veroboard Layout.



GRAPHICS

Toolkit software helps define user graphics



Using the graphics generator, which was built from our first issue, as a base, Tony Noel shows how it can be used to produce and save a character set.

THE GRAPHICS GENERATOR project in our first issue attracted great interest. Now a reader, Tony Noel of Southampton, has provided a graphics toolkit program to assist in using the board to define your own graphics.

The program should be entered in two parts. The first section, labelled graphics, allows you to define the characters using the cursor keys on a grid of eight by eight. The second section, labelled graphic support, allows you to put the characters on tape for future reference.

First load 'graphics' and, when run, the program copies the Sinclair characters into CHR$ RAM automatically ready for the switch. To RUN the program after BREAK enter RUN 2999. The functions in detail are:

B—blots out a space.

W—whites out a space.

D—draws the shape below for clarity.

C—will copy the miniature version of the shapes on the grid in exchange for any other character. That takes time but, while it is doing it, it prints on the screen the memory location being processed.

N—will clear the grid.

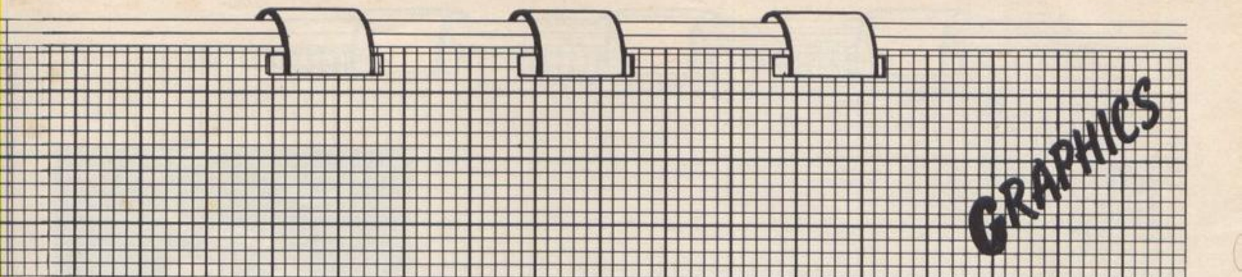
S—to start with a black grid.

When all the characters are defined, load graphic support, which provides four independent memories which at first are empty and unnamed.

Having done that, press S to save the characters in a memory. Provision is given for the contents of a memory to be named, for example Sinclair Codes or Space Invaders.

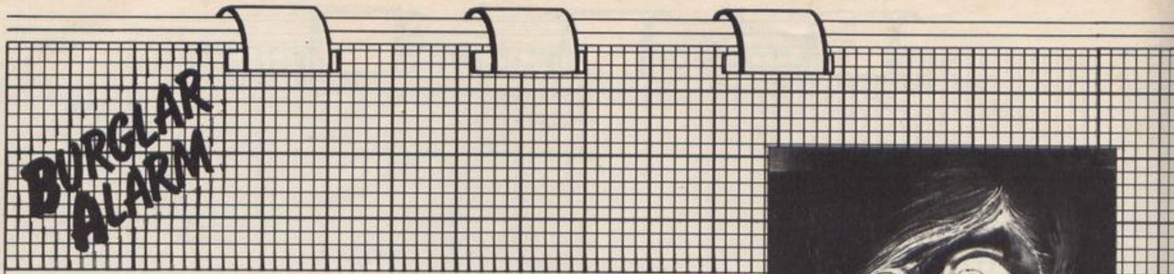
It will usually be desirable to store the data on cassette and a suitable prompt will appear. To load from a memory, press 6 and select a memory as instructed. When finished, the program may be cleared by pressing A.

```
   3 DIM N$(4,14)
   5 DIM R$(4,512)
  10 SAVE "GRAPHIC SUPPORt"
  20 CLS
  30 GOSUB 4000
  35 PRINT AT 9,0;"-------------
--------------------"
  40 PRINT AT 12,6;"PRESS ""S""
FOR SAVE";AT 16,12;"""L"" FOR LO
AD";AT 20,12;"""A"" FOR ABORT"
  50 LET I$=INKEY$
  60 IF I$="A" THEN NEW
  70 IF I$="L" THEN GOTO 100
  80 IF I$="S" THEN GOTO 120
  90 GOTO 50
 100 LET B=2000
 101 LET B$="LOADING"
 102 CLS
 104 PRINT AT 11,7;"WHICH MEMORY
?"
 105 GOSUB 4000
 106 INPUT C
 108 IF C<1 OR C>4 THEN GOTO 106
 110 IF B=1000 THEN LET N$(C)=T$
 115 GOTO 130
 120 CLS
 122 PRINT AT 11,3;"ENTER A NAME
FOR THE DATA"
 124 INPUT T$
 126 LET B=1000
 127 LET B$="SAVING"
 128 GOTO 102
 130 CLS
 132 PRINT AT 7,6;B$;" ";N$(C)
 135 PAUSE 100
 140 FAST
 145 LET A=15872
 150 FOR I=1 TO 512
 155 GOSUB B
 160 LET A=A+1
 170 NEXT I
 180 SLOW
 190 IF B=1000 THEN GOTO 3000
 200 GOTO 20
1000 LET R$(C,I)=CHR$ PEEK A
1010 RETURN
2000 POKE A,CODE R$(C,I)
2010 RETURN
3000 CLS
3010 PRINT AT 11,0;"DO YOU WANT
TO  STORE THE  DATA"
3020 PRINT AT 14,0;"ON  TAPE?
(RESPOND ""Y"" OR ""N"")"
3030 INPUT I$
3040 IF I$="N" THEN GOTO 20
3050 CLS
3060 PRINT AT 11,0;"PRESS ""PLAY
/RECORD"" ON CASSETTE"
3070 PAUSE 140
3080 GOTO 10
4000 PRINT AT 0,0;"DATA IN MEMOR
Y 1: ";N$(1);AT 2,8;"MEMORY 2: "
;N$(2);AT 4,8;"MEMORY 3: ";N$(3)
;AT 6,8;"MEMORY 4: ";N$(4)
4010 RETURN
```



Graphics Program

```
   2 GOTO 3000
   3 GOTO 2000
  10 FOR I=1 TO 9
  20 PRINT AT I-1,0;"O";AT I-1,9
;"O"
  25 PRINT AT 0,I-1;"O";AT 9,I-1
;"O"
  30 NEXT I
  31 PRINT AT 9,9;"O"
  35 DIM G$(8,8)
  40 LET X=1
  50 LET Y=1
  55 GOSUB 1000
  60 PRINT AT X,Y;"*"
  65 PRINT AT X,Y;" "
  66 PRINT AT X,Y;G$(X,Y)
  70 IF INKEY$="" THEN GOTO 60
  72 LET X$=INKEY$
  75 GOTO 80+30*(CODE X$>37)
  80 LET X=X+1*(X$="6" AND X<8)-
1*(X$="7" AND X>1)
  90 LET Y=Y+1*(X$="8" AND Y<8)-
1*(X$="5" AND Y>1)
 100 GOTO 60
 109 IF X$="" THEN GOTO 60
 110 GOTO 700*(X$="S")+3+200*(X$
="B")+300*(X$="W")+400*(X$="C")+
500*(X$="N")+600*(X$="D")
 203 LET G$(X,Y)=" "
 204 GOTO 60
 303 LET G$(X,Y)=" "
 305 GOTO 60
 403 GOTO 1500
 503 FOR I=1 TO 8
 507 LET G$(I)="        "
 510 PRINT AT I,1;G$(I)
 520 NEXT I
 521 LET X=1
 522 LET Y=1
 530 GOTO 60
 603 FOR I=1 TO 8
 605 PRINT AT 12+I,0;G$(I)
 607 NEXT I
 609 PAUSE 120
 611 FOR I=1 TO 8
 620 PRINT AT 12+I,0;"        "
 625 NEXT I
 630 GOTO 60
 703 FOR I=1 TO 8
 704 LET G$(I)="(8*isP )"
 708 PRINT AT I,1;G$(I)
 710 NEXT I
 720 GOTO 60
1000 PRINT AT 12,12;"FUNCTIONS;-
"
1010 PRINT
1020 PRINT TAB 15;"B-BLACKOUT"
1030 PRINT TAB 15;"W-WHITEOUT";T
AB 15;"C-COPY";TAB 15;"N-NEW";TA
B 15;"D-DRAW ";TAB 15;"S-SHADE"
1040 PRINT AT 0,14;"MOVE ASTERIS
K";AT 2,14;"WITH CURSOR KEYS"
1050 RETURN
1500 PRINT AT 21,0;"WHICH CHARAC
TER IS TO BE CHANGED"
1505 INPUT C$
1510 LET C=CODE C$
1520 IF C<64 THEN GOTO 1530
1522 PRINT AT 21,0;"CODE IS TOO
GREAT.TRY AGAIN."
1523 PAUSE 65
1524 GOTO 1500
1530 LET M=15872+C*8
1532 PRINT AT 9,17;CHR$ C;AT 9,2
3;CHR$ (C+128)
1540 FOR I=1 TO 8
1541 LET T=0
1542 FOR N=1 TO 8
1544 LET T=T+2**(8-N)*(G$(I,N)="
 ")
1550 NEXT N
1552 POKE M+I-1,T
1553 PRINT AT 5,15;M+I-1;" ";T
1560 NEXT I
1570 PRINT AT 21,0;"
                    ";AT 5,15;"
           "
1580 GOTO 60
2000 PRINT AT 21,0;"ILLEGAL CODE
"
2005 PAUSE 73
2006 PRINT AT 21,0;"
"
2010 GOTO 60
2999 SAVE "GRAPHICs"
3000 CLS
3001 PRINT "SUCCESSFUL LOADING"
3005 PRINT AT 11,0;"SWITCH OFF C
ASSETTE RECORDER"
3010 PAUSE 170
3020 PRINT AT 11,0;"PLEASE WAIT
WHILE DATA IS MOVED"
M"
3040 PAUSE 246
3050 FAST
3060 LET U1=15872
3070 FOR I=7680 TO 8191
3080 POKE U1,PEEK I
3090 LET U1=U1+1
3095 NEXT I
4000 CLS
4010 SLOW
4020 PRINT "TRANSFER COMPLETE."
4030 PRINT AT 11,0;"MAKE SWITCH
NOW"
4040 PAUSE 163
4050 CLS
4060 GOTO 10
```



Alarming trend can be reduced by flexible system

With burglary increasing people are considering ways of protecting their property. Corin Howitt explains how the Spectrum can be used to produce an effective alarm.

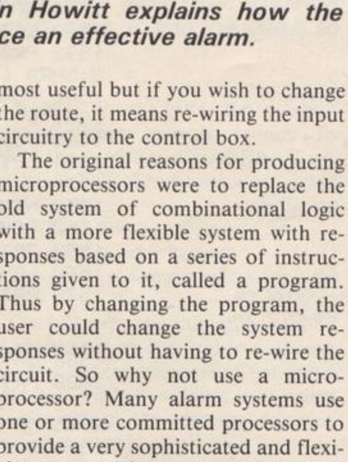
BURGLARY IS becoming more common today. Burglars also seem to be choosing their targets with less logic, i.e., having few valuable goods does not seem to prevent intrusion. Vandalism is also on the increase and that can be more distressing than being burgled by a selective professional who does not take the trouble to destroy possessions he cannot sell immediately. So many people have decided to invest in a burglar alarm system. Until recently, the price of even a simple system put it beyond the means of most householders but with the continuously-falling prices of components, most people can now afford an alarm system of some kind.

Most alarm systems in use and on sale employ combinational logic to provide a set number of normally-open loops — inputs which trigger when closed — and normally-closed loops — inputs which trigger when opened. That is satisfactory for most people but has disadvantages. If you want to have parts of the system operative while the rest is switched-off, for example at night, you would have to employ either a zone-switching system at the control box or change the system wiring.

The first is the most useful but incorporating extra zones tends to cost more. Many systems employ entry/exit delay modes whereby the householder has a pre-set time to leave his premises after switch-on to set the alarm and has a pre-set time to re-enter by a set route and switch-off before the alarm triggers. That is most useful but if you wish to change the route, it means re-wiring the input circuitry to the control box.

The original reasons for producing microprocessors were to replace the old system of combinational logic with a more flexible system with responses based on a series of instructions given to it, called a program. Thus by changing the program, the user could change the system responses without having to re-wire the circuit. So why not use a microprocessor? Many alarm systems use one or more committed processors to provide a very sophisticated and flexible system. Those systems are very expensive, because of the amount of support chips and little details a processor requires to operate properly, and such systems are used only where the level of security required justifies the cost.

Figure 3. SCR1 pin-out.

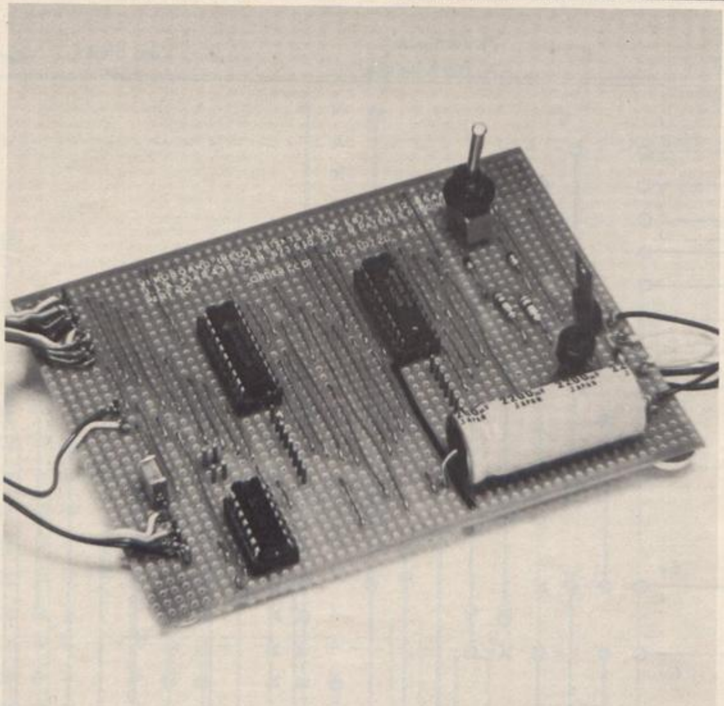


The next best thing to using a committed processor is to use a non-committed one. A Z-80A is present in the Spectrum and it is the power of the computer we will use to provide a very flexible alarm system. Sir Clive kindly provided us with the Z-80 instructions IN and OUT direct from the keyboard. Those instructions give us direct access to the 64K I/O space the Z-80 can handle.

Sinclair Research uses a rather simple method of I/O decoding which enables a peripheral by taking one of the address lines A0 to A4 low at the same time as $\overline{IORQ}$. Page 159 of the Spectrum manual tells us that bits A5, A6 and A7 of the address bus are ours with which to do what we want, providing AØ to A4 are high.

All we need to do is to put an I/O port at a memory address which takes either A5, A6 or A7 low. Address 65503 takes address line A5 low and all others high.

As page 159 of the manual will indicate, OUT and IN act much in the same way as POKE and PEEK, except that they act on the 64K I/O space. IN x reads a single-byte number into the computer from port x. OUT x,y puts a byte y into port x. Those two instructions cause the $\overline{IORQ}$ line to go low. $\overline{IORQ}$ stands for input/output request and indicates that the Z-80 is requesting a number if IN is used, or giving a



COMPONENT SUPPLIERS

Many stock alarm accessories. A good one is A D Electronics, which will supply a free catalogue on request. Both Maplin and Tandy stock a small selection of accessories.

A D Electronics, Mail Order Dept., 217 Warbreck Moor, Aintree, Liverpool L9 0HU.

COMPONENTS LIST

Resistors
R1-2 1k ¼W

Capacitors
C1 2200µF 25V
C2 100n polycarbonate

Semiconductors
D1-3 1N4148
BR1 W005
SCR1 C106D
IC1 74LS273
IC2 74LS244
IC3 74LS32

Miscellaneous
SW1—SPDT toggle
SW2—DPDT mains toggle
TR1—0-6, 0-6 6VA transformer
23+23 ZX-81 connector
or 28+28 Spectrum connector
Ribbon cable, wire.
12V burglar alarm bell.
Veroboard, 36 strips × 50 holes.
Small stick-on rubber feet, four.

number if OUT is used. The lines which indicate whether a number is wanted or if a number is given are $\overline{RD}$ and $\overline{WR}$. $\overline{RD}$ goes low when the computer want to read a number into itself, i.e., IN. $\overline{WR}$ goes low when the computer wants to read a number into a port, i.e., OUT.

So with that information, we can design the interface; figure one shows the resulting circuit.

IC3a ORs together A5 and $\overline{IORQ}$, providing a low output when both inputs are low. That shows the computer wants I/O and is addressing the correct port. That output is taken to the inputs of IC3b and IC3c. IC3c ORs together our request signal and $\overline{RD}$, providing a low output when request and $\overline{RD}$ are both low, happening when IN 65503 is executed. Similarly the output of IC3b goes low when OUT 65503, y is executed.

IC1 is a 74LS273 octal d-type flip-flop — an 8-bit latch. The inputs to that latch are all connected to the data bus so that when pin 11 returns high the data bus values are transferred on to the outputs of the latch. Thus we have a method of outputting a number.

The input stage must allow the computer to read an 8-bit binary number on to the data bus. If we used a simple latch the number would always be present on the data bus and would cause all kinds of problems inside the computer.

For that reason IC2 is a 74LS244 octal tri-state buffer; all eight outputs can be either a 1, a 0 or in a high-impedence state. That third state occurs whenever the chip is not enabled and isolates it from the data bus. When the chip is disabled, it acts as if it were not there. The outputs from the chip are connected to the data bus, so when pins 1 and 19 go low, the chip is enabled and the input lines are put on to the data bus.

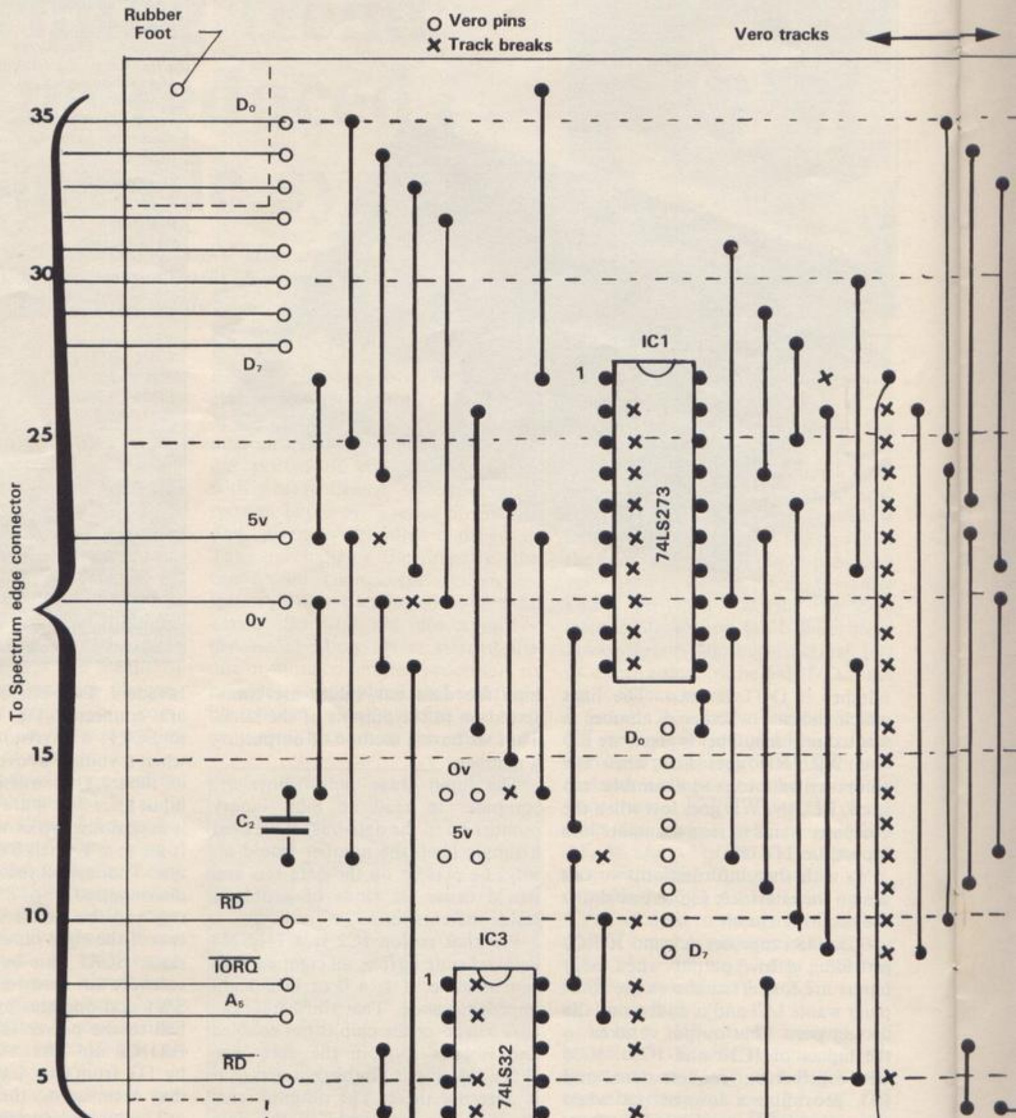
Most people who own a computer do not use it for a single purpose, so this circuit makes allowance for the user wanting the odd game of Space Invaders. Two bits of the input port are connected via R1,2 and D1,2 to SCR1, a thyristor which triggers when a voltage above 0V8 appears at its input. That will happen if either input lines 7 or 8 are high when SW1 is in position two or when output bit 0 is set to a 1 when SW1 is in position one. That means the computer can be disconnected when SW1 is in position two and the circuit will still monitor two of the eight input lines for a high state. SCR1 can be triggered from software or hardware depending on SW1 and operates by connecting the bell to the power supply formed by BR1,C1 and TR1. SCR1 is protected by D3 from any back e.m.f. which may occur across the bell.

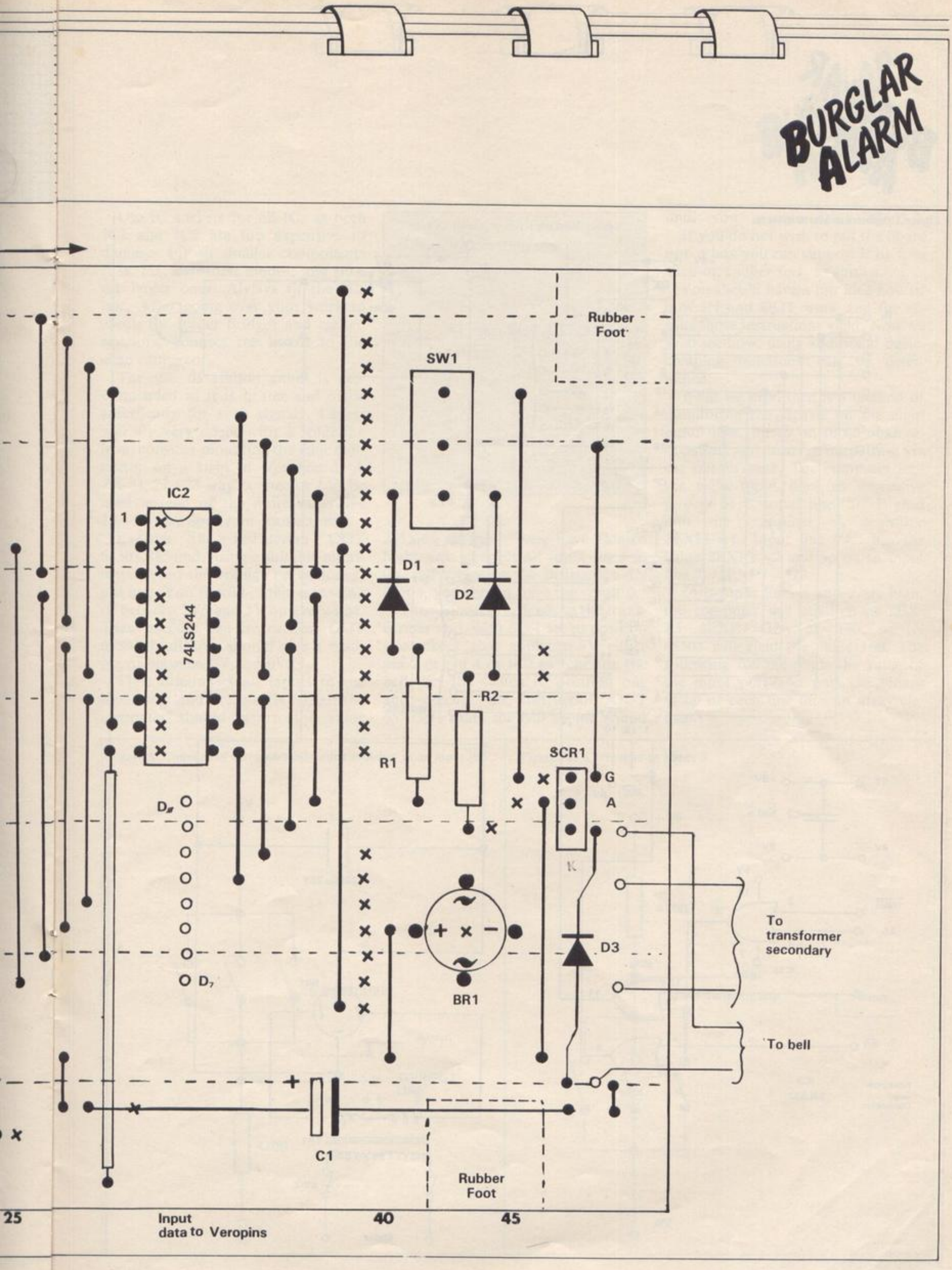
The power supply for the chips IC1-3 is derived from the computer after being decoupled by C2. The bell is driven by the second power supply formed by TR1, BR1 and C1.

If the demand is sufficient I would be ready to supply readers with a pre-drilled and etched PCB for £8.50.

BURGLAR ALARM

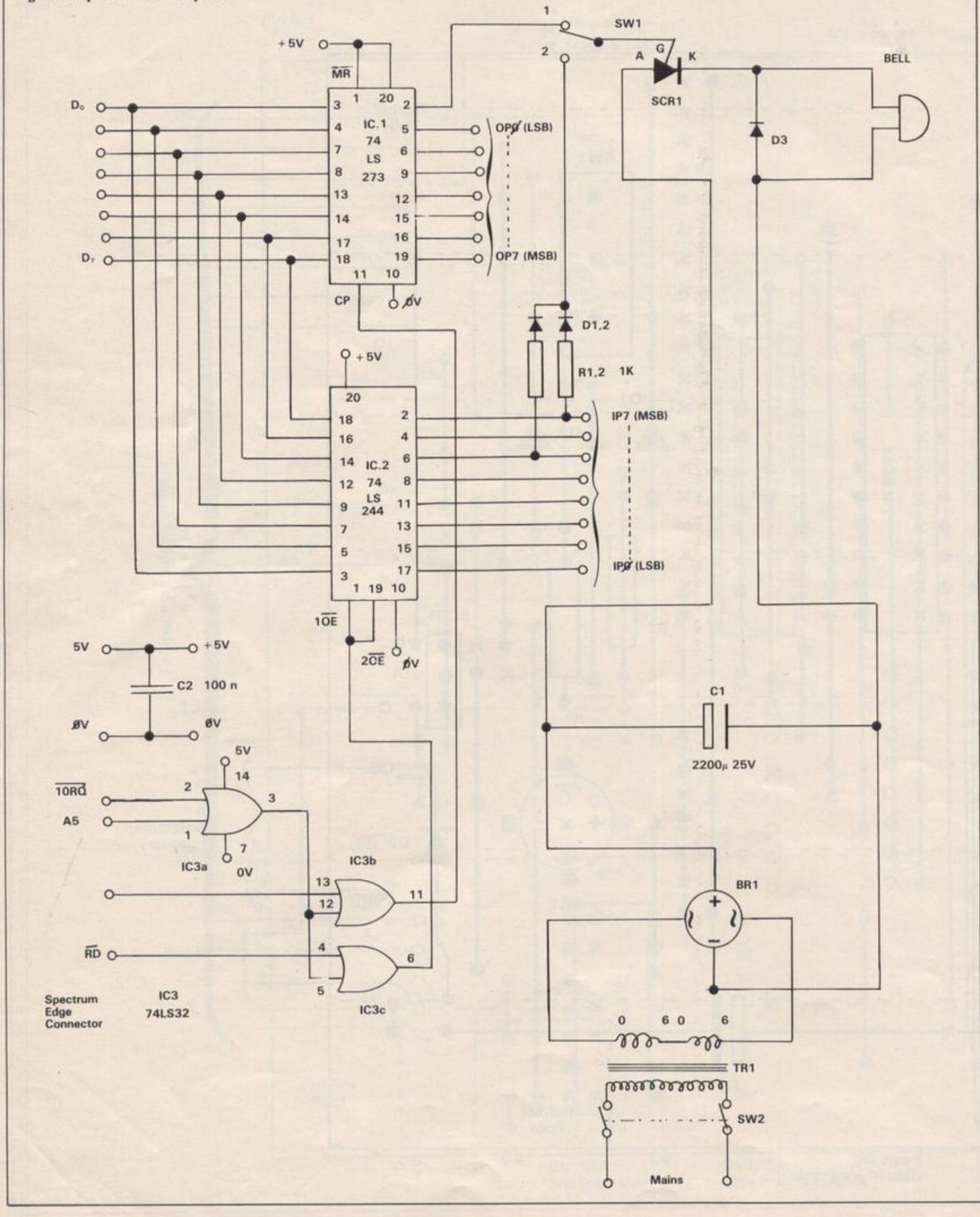
Figure 2.




Rubber Foot
SW1
IC2
1
74LS244
D1
D2
R1
R2
SCR1
G
A
K
D7
BR1
D3
To transformer secondary
To bell
C1
Rubber Foot
25
Input data to Veropins
40
45

BURGLAR ALARM

Figure 1. Spectrum alarm system.



Use IC sockets for all ICs as both IC1 and IC2 are too expensive to damage. Fit all smaller components first, i.e., resistors, diodes, and then the larger ones. Always fit the ICs last. After going over your work to check for solder bridges and melted resistors, connect the board to the edge connector.

The use of ribbon cable is recommended as it is neater and made specifically for such signals. Unless you are very adept with a soldering iron, consider mounting the edge connector on a strip of Veroboard. A ZX-81 23+23-way connector can be used instead of the more expensive 28+28-way Spectrum connector.

Execute the instruction OUT 65503,255 and, using a suitable multimeter, read the voltage on each output line. You should obtain a reading of between 2V5 and 5V on every line. Then execute the instruction OUT 65503,0, all lines should give a reading of between 0V and 0V5.

Then disconnect all inputs to the input port and execute IN 65503; the computer should return the value 255, as all input lines have floated high; next connect all input lines to 0V and repeating the instruction IN 65503, you should have the result 0.

Figure 4. Chart to show decimal values for each individual bit.

BIT	DEC (VAL)
7 (MSB)	128
6	64
5	32
4	16
3	8
2	4
1	2
0 (LSB)	1

Then connect the leads to the transformer and, with SW1 set to position two, check that applying 5V either pin 2 or pin 4 of IC2 switches-on the bell. Set the switch to position one and execute the instruction OUT 65503,1; again the bell should sound until you execute OUT 65503,0.

If you do not wish to put the board into a box you can support it by four stick-on rubber feet, as shown.

You should have a fair idea now of how IN and OUT work and the results those instructions yield. Now we shall see how, using additional Basic, complex functions can be determined.

What we need then is a method of monitoring the signals on the eight input lines. Based on those observations, act on them by outputting via the output port. The computer sees the eight input lines as successive powers of 2. Input line "0" is read into the computer as a value 2EXP0 = 1. Input line "1" has the value 2EXP1 = 2 and so on to input line 7 = 2EXP7 = 128.

So if input lines 5 and 7 are high, the computer will see that as 2EXP5 + 2EXP7 = 32 + 128 = 160, so IN 65503 will yield the value 160. The following routine reads the value of the input port and puts the binary value of each line into an array element:

Figure 5. Connecting three normally-open switches to an input line.

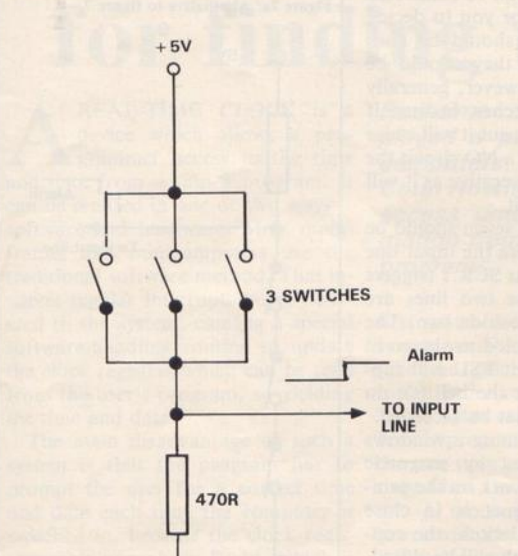
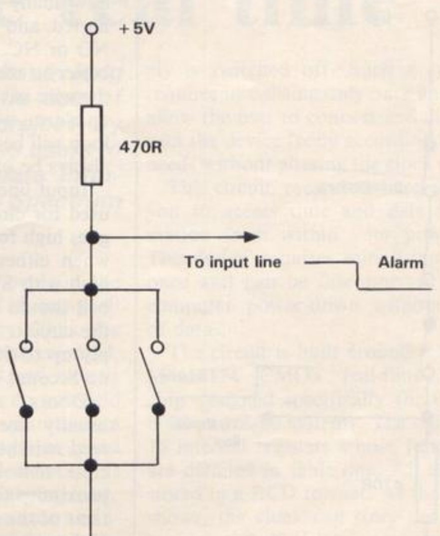
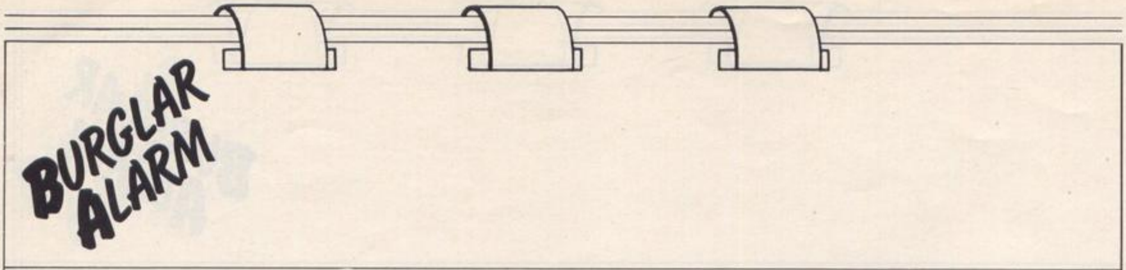


Figure 5a: Alternative to figure 5.






```
10 LET n=IN 65503
20 DIM a(8)
30 FOR c=1 to 8
40 LET a(c)=n-2*INT(n/2)
50 LET n=INT(n/2)
60 NEXT c
```

So with input lines 5 and 7 high, array elements 6 and 8 will have the value "1" while all other elements will have the value "0".

Outputting to the output port works in the opposite way. If you want to set output lines 5 and 7 you have to add 2EXP5 and 2EXP7 and put the result in the port. So 2EXP5+2EXP7 has the result 160; the instruction OUT 65503,160 will set them.

Broadly speaking, sensors fall into two categories, NO — normally open — and NC — normally closed. Figure five shows three NO switches connected to an input line, so that when any switch is closed the input line goes high, indicating to the computer that an alarm should occur.

Figure seven shows three NC switches connected to an input line, so that if any switch is opened the input line will go low, again indicating an alarm. Figures 5a and 7a show alternative circuits; in 5a the computer input line goes low for alarm and in 7a the line goes high for alarm.

Figure 7. Connecting three normally-closed switches to an input line.

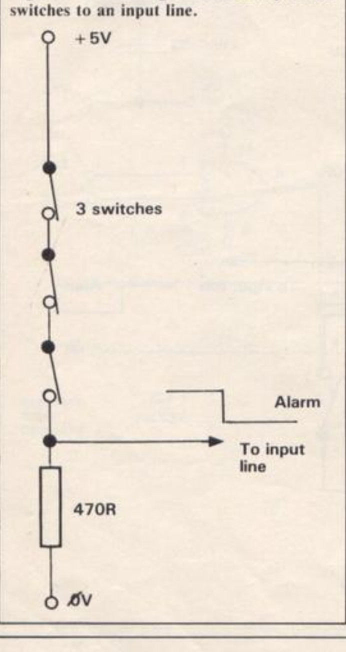
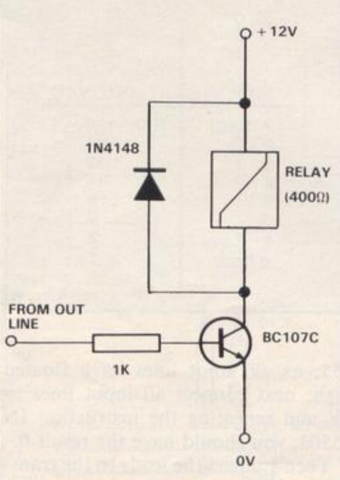


Figure 6. Connecting a relay to an output line.



Up to eight loops can be connected to the system; it is for you to decide how many switches should be connected and whether they should be NO or NC. It is, however, generally better to use NC switches, because if the wire in the loop is cut it will cause an alarm, whereas in a NO circuit the loop will become inoperative as it will always be open-circuit.

Input lines six and seven should be used for circuits where the input line goes high for alarm as SCR.1 triggers when either of those two lines are high with SW.1 in position two. The bell should be connected as shown in the circuit. The circuit PSU will supply up to 500mA for the bell (s); on no account should that be exceeded.

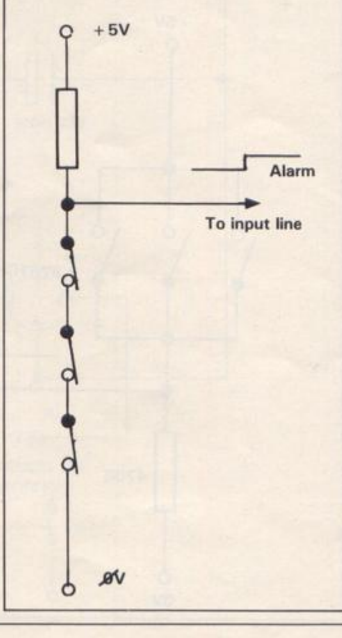
Doors and opening windows usually are protected by magnetic reed switches. They work on the principle that if a magnet is in close proximity to a reed switch, the contacts of the reed switch will be closed. If the magnet is moved away from the reed switch, at a certain distance the reed switch will open, breaking the circuit. The distance at which the reed switch first operates is called the operating point and that is specified in suppliers' data.

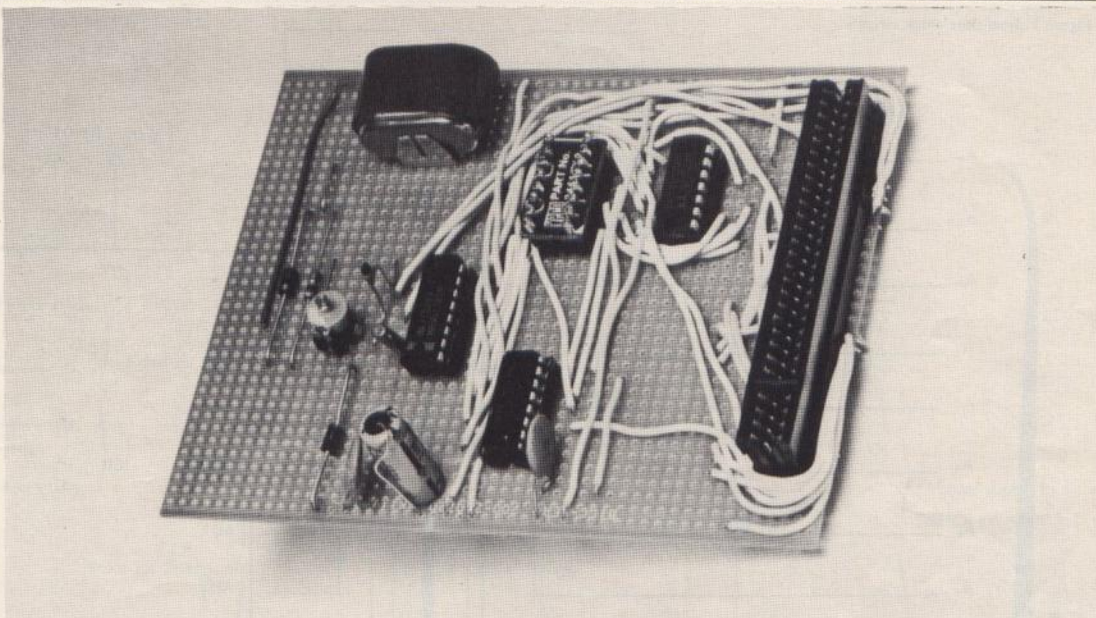
If we install a magnet into a door and a reed switch opposite it in the frame we can determine whether the door is open or closed by the state of the reed switch contacts. When buying magnet-reed switch pairs, always make sure the gap between door and frame keeps the reed switch within its operating distance when the door is closed. Many types of reed switch are available in different shapes, sizes and colours.

Glass in windows is usually protected by glueing a thin strip of aluminium foil on to the pane; that will break if the window is damaged, causing a break in the NC circuit in which it is connected. There are many other ways in which glass can be protected, including vibration and frequency-band sensors which are available from specialist suppliers.

To wire the system use PO-type four-core wire which is obtainable from all the suppliers listed.

Figure 7a: Alternative to figure 7.





Clocking into the program for finding the real time

Real-time clocks have long played a part in the use of computers. This project by Corin Howitt enables users to access time and date information from within Spectrum programs.

A REAL-TIME CLOCK is a device which allows a programmer access to the time and date from within a program. It can be realised in one of two ways—software and hardware. Most mainframes and minicomputers use the traditional software method. That involves regular interrupts being delivered to the system, causing a special software-handling routine to update the clock registers which can be read from the user's program, so yielding the time and date.

The main disadvantage of such a system is that the program has to prompt the user for a correct time and date each time the computer is switched in, because the clock registers are obviously in RAM, which is volatile.

The Spectrum has a system which is much like this. When the computer is first switched on, three bytes in the system variables area of memory all take the value 0. Every 20ms the lowest order register is incremented. Those bytes can be read and altered from a program but they do not yield the true time and date and store data only when the computer is switched on. A more detailed description is provided in chapter 18 of the manual.

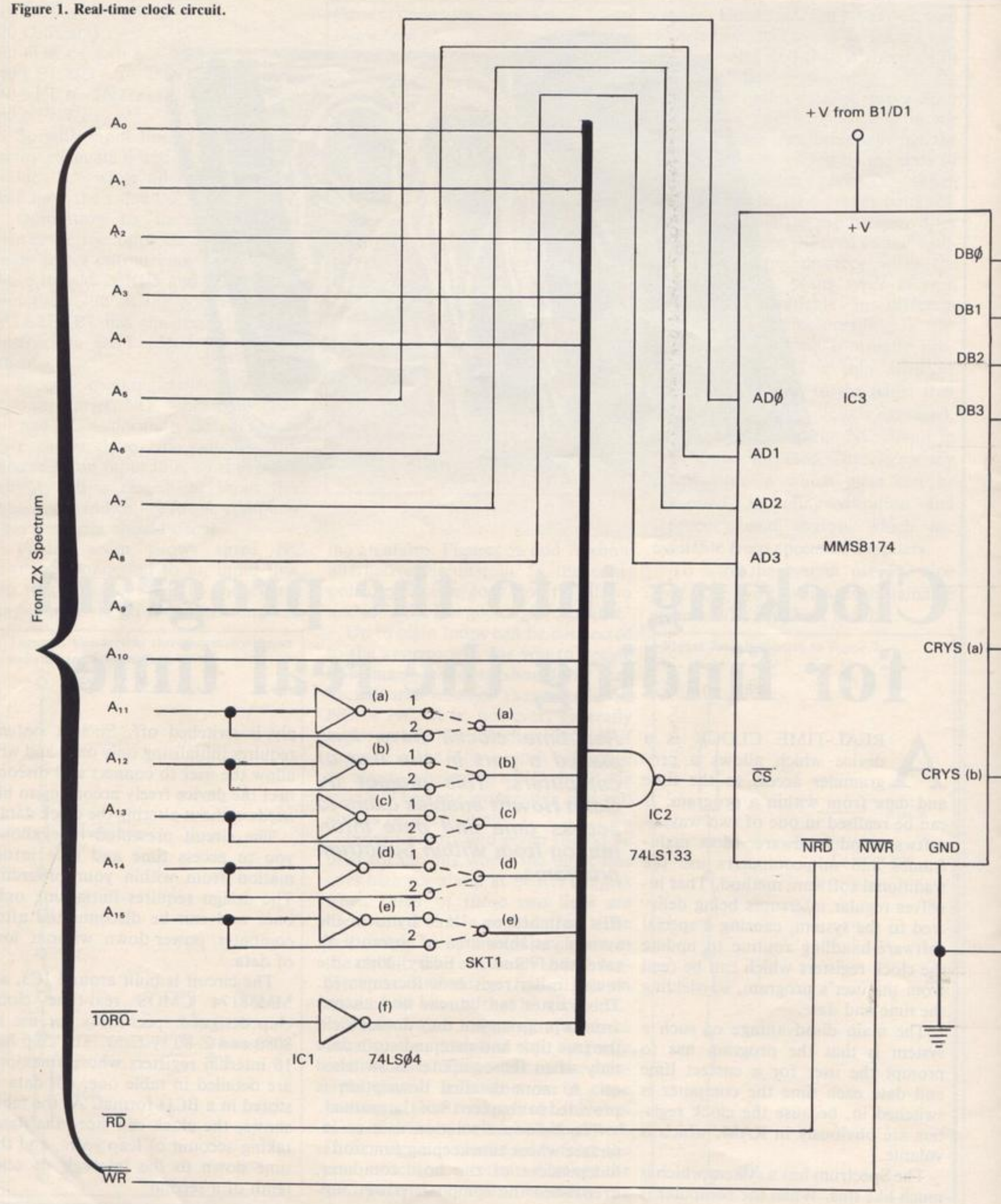
The hardware solution uses an interface whose timekeeping function is independent of the host computer, even when the computer power supply is switched off. Such a system requires initialising only once and will allow the user to connect and disconnect the device freely according to his needs without altering the clock data.

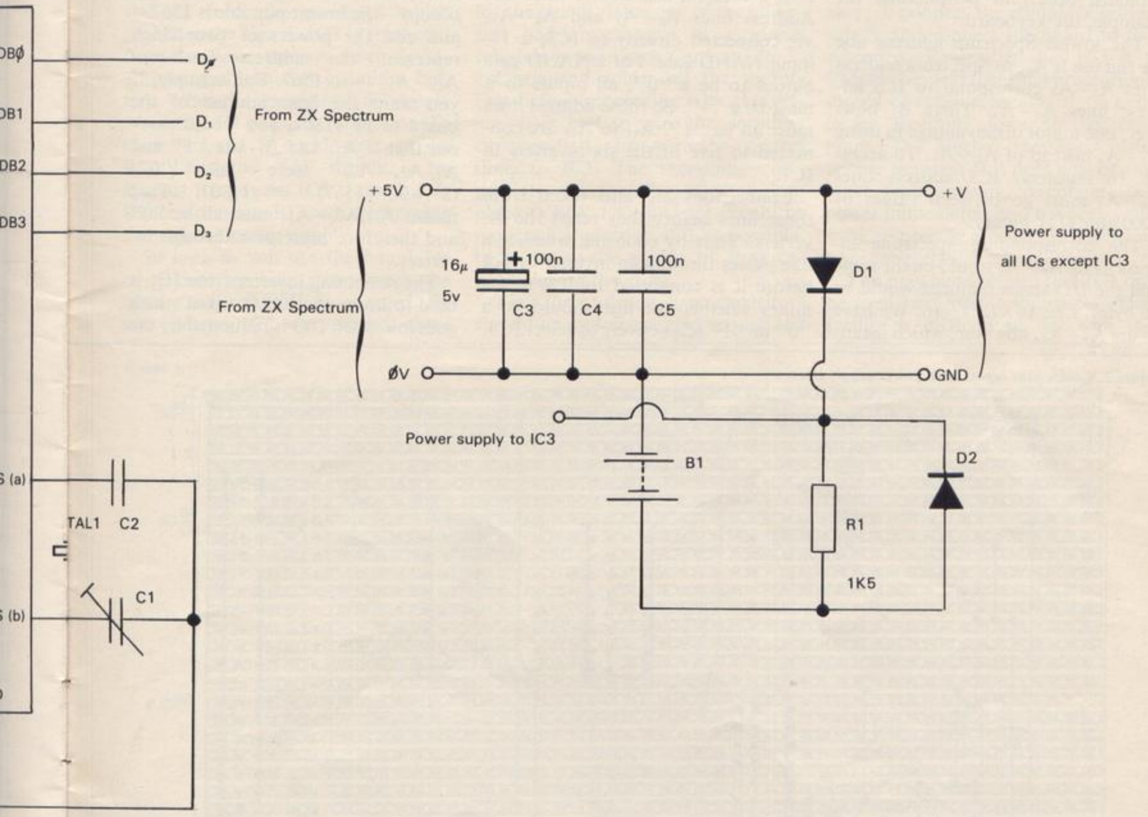
The circuit presented here allows you to access time and date information from within your program. The design requires initialising only once and can be disconnected after computer power-down without loss of data.

The circuit is built around IC3, an MM58174 CMOS real-time clock chip designed specifically for use in 8080 and Z-80 systems. The chip has 16 internal registers whose functions are detailed in table one. All data is stored in a BCD format. As the table shows, the clock can store the date, taking account of leap years, and the time down to the intervals of one-tenth of a second.

REAL-TIME CLOCK

Figure 1. Real-time clock circuit.




DBØ
DB1
DB2
DB3
$D_Ø$
D_1
D_2
D_3
From ZX Spectrum
+5V
ØV
From ZX Spectrum
16μ
5v
C3
100n
C4
100n
C5
D1
+V
Power supply to
all ICs except IC3
GND
Power supply to IC3
B1
D2
R1
1K5
S (a)
TAL1
C2
C1
S (b)

REAL-TIME CLOCK

The 16 internal registers are addressed by the four address lines $A_0 - A_3$. Looking at the circuit — figure one — you would expect chip address lines $A_0 - A_3$ to be connected directly to the Spectrum address lines $A_0 - A_3$. Unfortunately that is not possible, since Spectrum address lines $A_0 - A_4$ are reserved for use by the standard Spectrum peripherals, for example, the keyboard.

The lowest Spectrum address line we can use is A_5, so Spectrum address lines $A_5 - A_8$ correspond to IC3 address lines $A_0 - A_3$. There is, however, one major disadvantage in using $A_5 - A_8$ instead of $A_0 - A_3$. To access all 16 registers, IC3 address lines $A_0 - A_3$ must go between values of 0000 and 1111 binary.

The corresponding Spectrum address using $A_0 - A_3$ would be the same and the I/O space required would be 16 bytes, i.e., $16 \times (2^0) = 16$. We have to use $A_5 - A_8$, however, which means the I/O space required goes up by 32 bytes for each register, so our figure jumps to 512 bytes, i.e., $16x(2^5) = 512$. That should not be a disadvantage as the address mapping of the board is flexible and you can choose which 512 bytes of I/O space the board occupies.

The address decoding is based on IC1, a 74LS04, and IC2, a 74LS133. Address lines $A_0 - A_4$ and $A_9 - A_{10}$ are connected directly to IC2, a 13-input NAND gate. For a NAND gate output to be a "0", all inputs to it must be a "1". So those address lines must all be "1". A_{11} to A_{15} are connected to five of the six inverters in IC1.

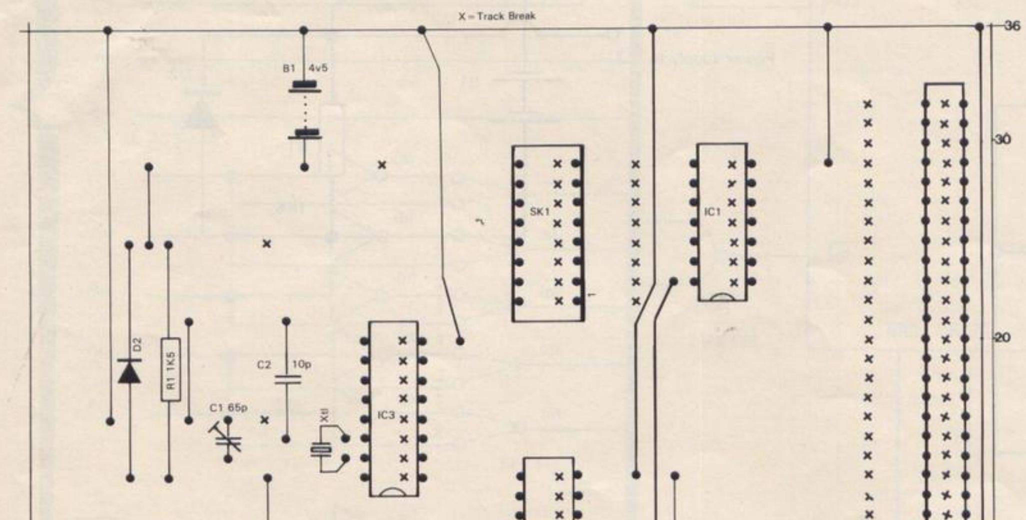
Connections are also taken from those lines before they reach the inverters. Thus by choosing whether a line passes through an inverter or not before it is connected to IC2 determines whether the line should be a "0" or "1" respectively to select IC3. The lines from the inverters and from those address lines are taken to a DIL socket together with the inputs to IC2.

By wiring a DIP plug suitably and inserting it into this socket, you can determine which I/O block the board occupies.

The best way to do it is to decide the lowest address the board is to occupy—the lowest possible is 1567—and add the powers of two which represent the address lines — $A_{11} - A_{15}$ — to 1567. For example, if you want the base address of the board to be 11807, you would work out that if A_{11} and A_{13} are "1" and $A_{12}, A_{14} - A_{15}$ were all "0", $(2^{11} + 2^{13} + 1567) = 11807$. That means $A_{12}, A_{14} - A_{15}$ must all be "0" and therefore must pass through inverters.

The remaining inverter from IC1 is used to invert the $\overline{\text{IORQ}}$ signal which goes low when I/O is requested by the

Figure 2. Component layout with power supply lines.



REAL-TIME CLOCK

Z-80. The $\overline{RD}$ and $\overline{WR}$ lines from the Z-80 are connected directly to the corresponding inputs on IC3; no signal conversion is required.

All data being stored in a BCD format, only four data lines are required; they are connected to the Spectrum data lines $D_0 - D_3$.

IC3 requires a clock running at 32.768KHz to operate. XTAL,C1 and C2 form the oscillator which generates the signal. IC3 is protected from data loss at power-down by B1, a rechargeable nickel cadmium battery. When the Spectrum +5V supply is present, D1 passes it to IC3. At the same time B1 is trickle-charged via R2. When the +5V supply is removed, B1 powers IC3 through D2; D1 then prevents B1 from discharging through the power supply.

So long as you use the board for more than an hour every week the battery will remain fully-charged. B1 will power IC3 for about three months if fully-charged when the supply is first removed. Capacitors $C_3 - C_5$ decouple the power supply to the ICs.

The board is constructed on a standard piece of Veroboard—3.75×5in. A general layout is shown in figure two. The pinouts of IC1-3 and SK1 are shown in figure three. Using the two diagrams, draw a wiring schedule for the circuit. Issue one of the magazine had an example of a wiring schedule in the Latch Card article.

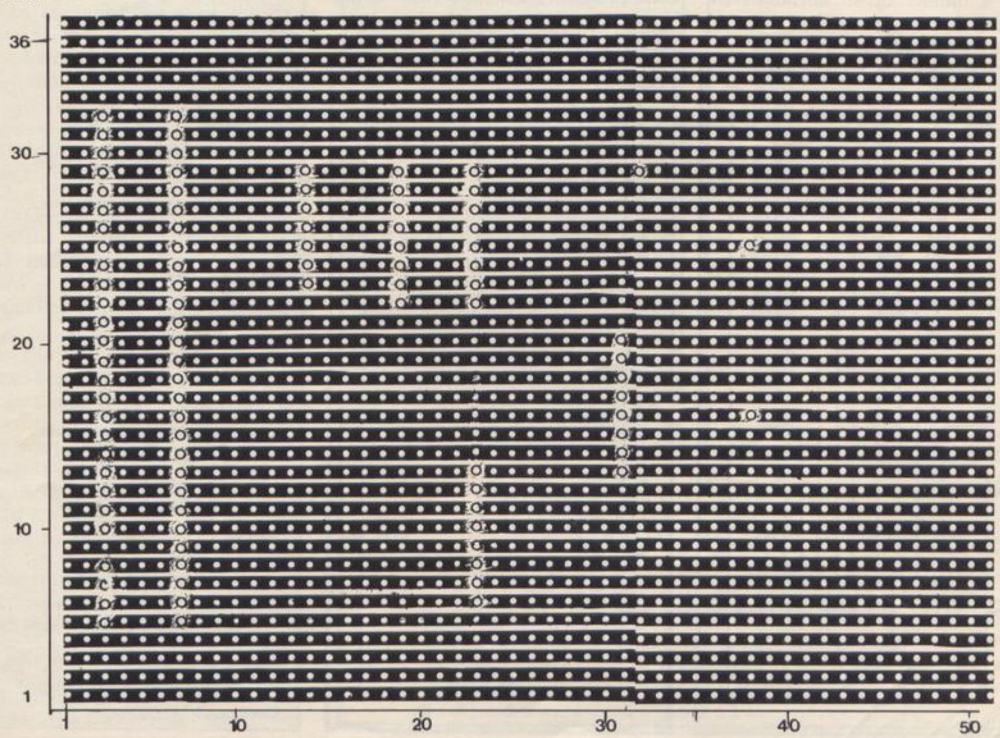
Insert and solder all the sockets first before proceeding with the wiring. It is best to wire the decoding circuitry first, then wire the connections to IC3. The remaining components can then be soldered into place. XTAL 1,C1 and C2 should be mounted as close to IC3 as possible, to minimise the effects of stray capacitance on the clock.

The three decoupling capacitors should be well distributed around the board. The photograph shows the suggested way of orientating the components. Before inserting the ICs, check to see whether there are any unintentional solder joints or forgotten track breaks which could cause problems. Also use a multimeter to test the battery voltage; it should be 3V6.

If all is well, insert the IC3 and DIP plug, disconnect the computer power supply and connect the board to the computer. Remember that IC3 is a CMOS chip and the usual precautions should be taken regarding static electricity. Re-apply power to the computer. The Sinclair message should appear as usual. If it does not, or any other fault appears, disconnect the power immediately and re-check your work, especially around the Spectrum edge connector.

You may have noticed that IC3 can be used to generate interrupts. This facility is difficult to use with the

Figure 3.



REAL-TIME CLOCK

Spectrum as other peripherals generate interrupts—for example, the keyboard; if you did, the computer would probably crash.

Now that you have a working board, I will demonstrate how to program the interface. The first thing to do must obviously be initialising the clock to the correct time and date. Routine one achieves that. The program first prompts you for the start address of the board; that is the address of register one. Then you are requested to enter the data in the form shown as a$, line 30; it takes the board out of test mode by writing a zero to clock register 0, stops the clock and disables interrupts by writing zeros to clock registers 14 and 15. The following FOR-NEXT loop slices a$ into individual numbers and puts those numbers into their corresponding registers. When that task is finished, the program waits for you to press a key, then starts the clock.

It would be a good idea to enter a time a minute or so ahead of the existing time and press ENTER when that time is reached.

Reading the clock is a little more difficult. The clock updates every one-tenth of a second, which implies that the program has 100ms to read all the registers. Spectrum Basic could achieve that but you cannot use a FOR-NEXT loop in this case; it would be too slow.

To conserve memory and improve speed, machine code is used. Each time the clock updates its internal registers an internal update flip-flop is also set. To re-set the flip-flop the clock must be read once. Also when an update has occurred, a value of 15 is written to all readable registers.

The program must detect that as a signal to proceed with the read. A point to note is that the circuit of figure one does not affect the top four data bits; they will all be high. That means the result will be meaningless unless the value 240 is subtracted or a machine code AND 15 instruction is used.

Routine two contains the machine-code program—machine code listing shown as routine three—in data statements. That routine enters the ma-

Figure 4

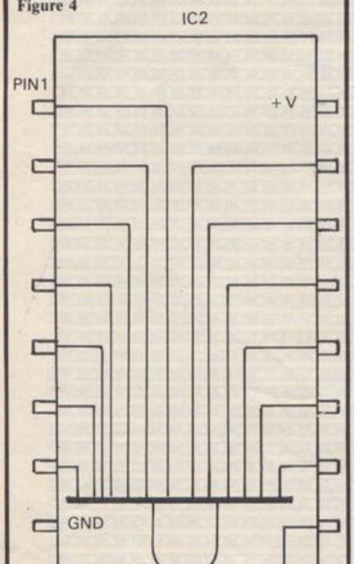


Figure 5

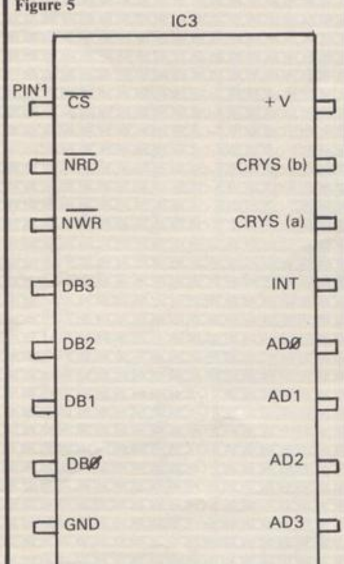
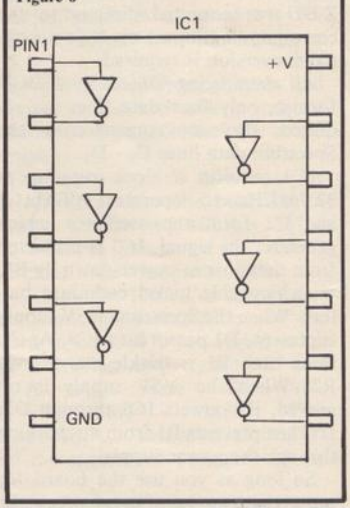


Figure 6



COMPONENTS LIST

Integrated circuits

IC1 74L504
IC2 74LS133
IC3 MM58174*
D1,2 1N4001

Capacitors

C1 65pF trimmer—0.1in. spacing
C2 10pF ceramic plate
C4-5 100pF ceramic disc
C3 16μF electrolytic

Resistors

R1 1K5 ¼W carbon

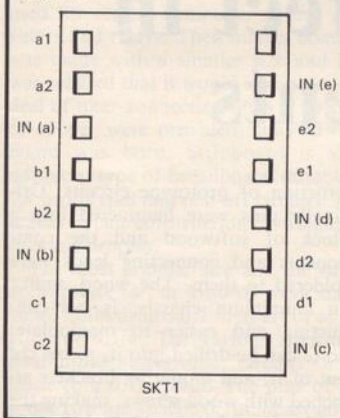
Miscellaneous

3V6 100mAH PCB-mounting ni-cad
(*Ambit Int.)
XTAL 32.768 kH₃ clock crystal
3 × 16-pin DIL socket
14-pin DIL socket
16-pin DIP plug
28 + 28 Zx connector
Veroboard 3.75 × 5in.
—50 holes × 36 strips.
Wire, solder

*IC3 is available from dealers such as Watford Electronics, Cricklewood Electronics.

REAL-TIME CLOCK

Figure 7.



chine code and allows you to enter the pointer bytes for the machine code program. You can then save the machine code and pointer bytes, under your chosen name, for use in other programs.

The assembler listing is shown as routine three. The program uses three user-defined variables. PTR—pointer— points to the address of the first register the user wants read. BLK—block—points to the start of the result block, where the values of the registers will be put in main memory.

NRG—number of registers—defines the number of registers to be read. BC is used as the pointer to the board and registers, HL is used as a destination pointer and DE is used as the counter. Line 130 clears the update flip-flop by reading the clock once. Lines 140-150 poll the clock until an update has taken place. The program then reads each register in succession, masking the tip nibble—AND 15—and places each result in successive memory locations starting at BLK. When DE=0 the routine returns to Basic.

The routine can be used only with a 16K Spectrum; 48K owners will have to change the program location and the variable bytes or write their own routine in Basic. When using routine two, remember the register number includes the first register read.

To run the machine code use RANDOMIZE USR 32506 or PRINT USR 32506; the last version should return the decimal address of the last register used.

Listing four is a simple Basic routine which calls the machine code routine of listing three and prints-out a heading followed by the time. For this program, routine three was arranged to put the results in memory from location 32550 onwards and SK1 wired for memory address location 65055.

MM58174 REGISTER DETAILS

REG.NO.	ACCESS	DETAILS
0	WR	1—TEST MODE, 0—NON TEST MODE
1	RD	1/10 s
2	RD	SECONDS
3	RD	10× SECONDS
4	RD/WR	MINUTES
5	RD/WR	10× MINUTES
6	RD/WR	HOURS
7	RD/WR	10× HOURS
8	RD/WR	DAYS
9	RD/WR	10× DAYS
10	RD/WR	DAY OF WEEK 1—MONDAY, 7—SUNDAY
11	RD/WR	MONTHS
12	RD/WR	10× MONTHS
13	WR	YEAR STATUS 1,2,4,8—leap year, +1, +2, +3
14	WR	STOP/START 0—STOP, 1—START
15	RD/WR	INTERRUPT 0 FOR NO INTERRUPTS

Routine 1.

```
5 LET b=1
10 INPUT "Start address?";ad
20 INPUT "Enter time and date in the form YMMWDDHMMM:";a$
30 OUT ad,0: OUT ad+448,0: OUT ad+480,0
40 FOR a=(ad+416) TO (ad+128) STEP -32
50 OUT a,(VAL a$(b))
60 LET b=b+1: NEXT a
70 PRINT "Press ENTER to start clock:": PAUSE 0
80 OUT ad+448,1: PRINT "The clock is running."
```

Routine 2.

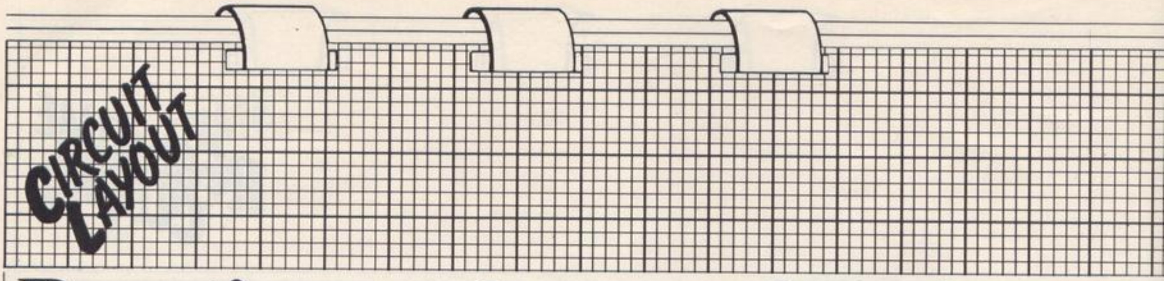
```
10 CLEAR 32499
20 FOR a=32506 TO 32545
30 READ d: POKE a,d
40 NEXT a
50 INPUT "Enter the address of the first  register to be read: ";z
60 POKE 32500,z-256*INT (z/256): POKE 32501,INT (z/256)
70 INPUT "Enter start address of result   block:";z
80 POKE 32502,z-256*INT (z/256): POKE 32503,INT (z/256)
90 INPUT "Enter register number:";z
100 POKE 32504,(z-1)
110 DATA 237,75,244,126,42,246,126,237,91,248
120 DATA 126,237,120,237,120,254,255,32,250,237
130 DATA 120,230,15,119,35,229,33,32,0,9
140 DATA 229,193,225,123,214,1,200,95,24,235
150 INPUT "What name to save?"; LINE a$
160 SAVE a$CODE 32500,99
170 PRINT "Machine code now saved onto tape"
```

Routine 3.

```
0060 PTR   EQU  32500
0070 BLK   EQU  32502
0080 NRG   EQU  32504
0090       ORG  32506
0100       LD   BC,(PTR)
0110       LD   HL,(BLK)
0120       LD   DE,(NRG)
0130       IN   A,(C)
0140 STAT  IN   A,(C)
0150       CP   255
0160       JR   NZ,STAT
0170 READ  IN   A,(C)
0180       AND  15
0190       LD   (HL),A
0200       INC  HL
0210       PUSH HL
0220       LD   HL,32
0230       ADD  HL,BC
0240       PUSH HL
0250       POP  BC
0260       POP  HL
0270       LD   A,E
0280       SUB  1
0290       RET  Z
0300       LD   E,A
0310       JR   READ
0320       END
```

Routine 4.

```
1 REM -- prog SEETIME
3 DIM a$(12)
5 PRINT "Mth Wk Day hr min sec"
7 RANDOMIZE USR 32506
10 FOR i=12 TO 1 STEP -1
20 LET a$(i)=CHR$ (48+PEEK (32550+i))
30 NEXT i
40 PRINT " ";a$(12);a$(11);" ";a$(10);"  ";a$(9);a$(8);" ";a$(7);a$(6);"  ";a$(5);a$(4);" ";a$(3);a$(2);".";a$(1)
```



Practice makes perfect in laying-out components

MANY ARTICLES in *Sinclair Projects* include full constructional details using Veroboard but you may wish to experiment with circuits you have seen elsewhere and occasionally limitations of space mean that it is not possible to show all the necessary details. So this explains how to produce a stripboard layout from a circuit diagram.

A later article will give details of various techniques which have been used in previous constructional articles and some hints and tips for constructors. It is hoped that this will save readers hours of experimentation and fault-finding.

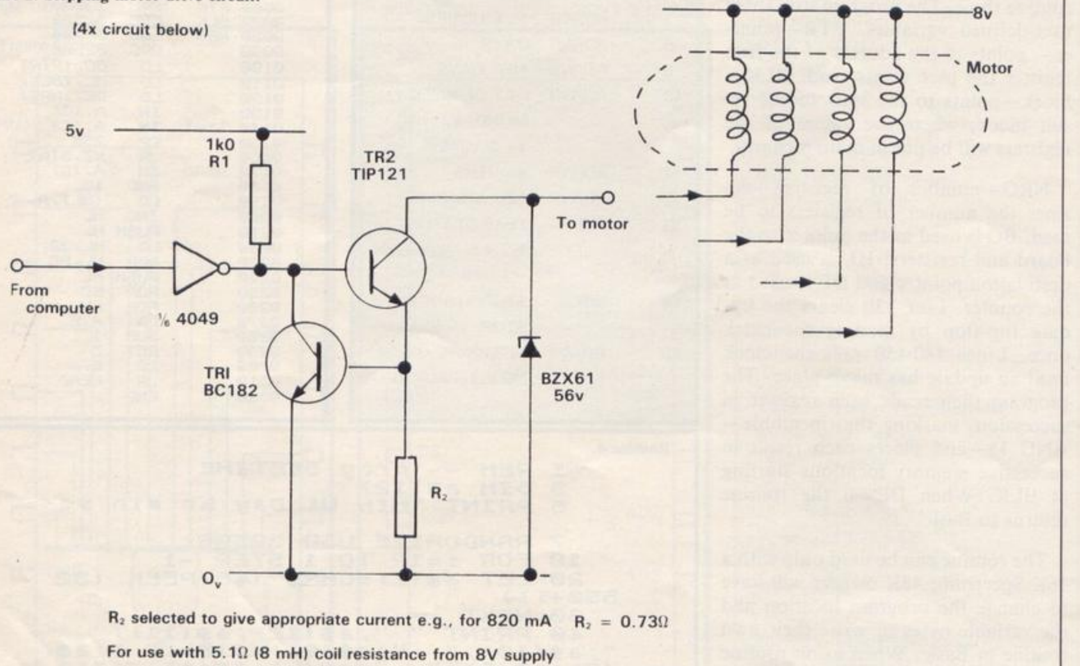
There are many ways of organising the layout of components in a project. John Mellor gives some advice on the best ways to ensure a simple and effective result.

We all had to start somewhere and we all have our favourite techniques. The only way to discover which suits you best is to take pencil, paper, soldering iron and components and try them. That is the practical side, not the theory of circuit construction, and the only way to learn it is by practice.

Breadboarding refers to the construction of prototype circuits. Originally pins were hammered into a block of softwood and the components and connecting leads were soldered to them. The wood, unlike an aluminium chassis, is non-conducting and easier to manipulate; holes can be drilled into it, pieces cut out of it, and mounting brackets attached with wood screws, making the production of the prototype a rapid and flexible process.

The softwood was replaced by pieces of insulating material such as Paxolin with a matrix of holes drilled into it into which turret tags were fitted in place of the pins used in the softwood. From the earliest days of

Figure 1. Stepping motor drive circuit.



R_2 selected to give appropriate current e.g., for 820 mA $R_2 = 0.73\Omega$

For use with 5.1Ω (8 mH) coil resistance from 8V supply

This circuit will drive a 28V stepper motor from an 8V supply

breadboarding sockets have been used for certain components such as valves and relays. Then matrix board was made with a smaller size and it was realised that it would save a good deal of inter-connecting links if strips of copper were provided; thus stripboard was born. Stripboard is an advanced type of breadboard suitable for prototypes and one-off circuits. It makes circuit construction a straightforward process.

The most popular size and the size appropriate to our kind of work has 1mm. holes drilled 0.1in. apart or at a pitch of 0.1in. The various sizes of dual-in-line integrated circuits are made to a 0.1in. grid. The pins of a single row are spaced 0.1in. apart and the two rows of pins are either 0.3in. for the smaller ICs or 0.6in. apart for the larger ICs, so that the pins on the IC will fit through the holes in the board.

It is recommended, though, that IC sockets are used at all times. They are well worth the small extra outlay for the convenience of being able to change ICs or check power and signal lines before the IC is inserted.

I will say more later about the various types of stripboard available and how it is used. Let us assume that we wish to build a circuit on standard stripboard which has 0.1in. pitch holes and continuous copper strips running from one end to the other.

On the circuit diagram the inter-connections between components are shown as lines; if two or more connections are made to the same point, a blob will be used to indicate that—see figure six.

When using matrix board for construction the blobs can be considered to represent pins in the board and the lines to represent either component leads or lengths of wire, and several leads can be connected to one pin. With stripboard it is possible to fit only one lead through each hole.

It is often a useful idea to label the inter-connections on the circuit diagram. Power rails will be labelled '+' and '−', inputs and outputs can be numbered or lettered, as can all the other junctions. Check that you have not labelled two points in a different way if they are connected electrically. Those inter-connections will each need a separate copper strip which can be broken at a hole to make two or more strips, or to break connections.

The circuit needs to be re-drawn to give an indication of how it will be laid out on the stripboard.

All the components connected to the same point need not be near each other.

A pencil, some coloured felt-tip pens, paper and access to certain information is required. Ordinary feint-ruled exercise paper will do though graph paper or exercise paper with a grid pattern or ruling may prove more helpful to the absolute beginner. Instead of using circuit symbols draw the outline or pinout of the component on to the ruled paper. Information on the pinout of components

Figure 2.

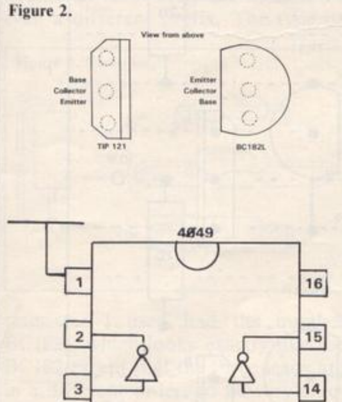
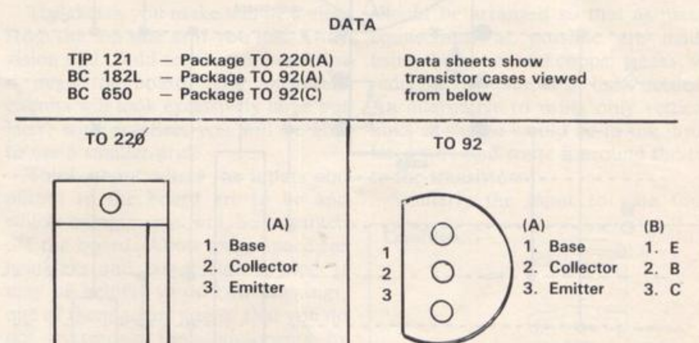
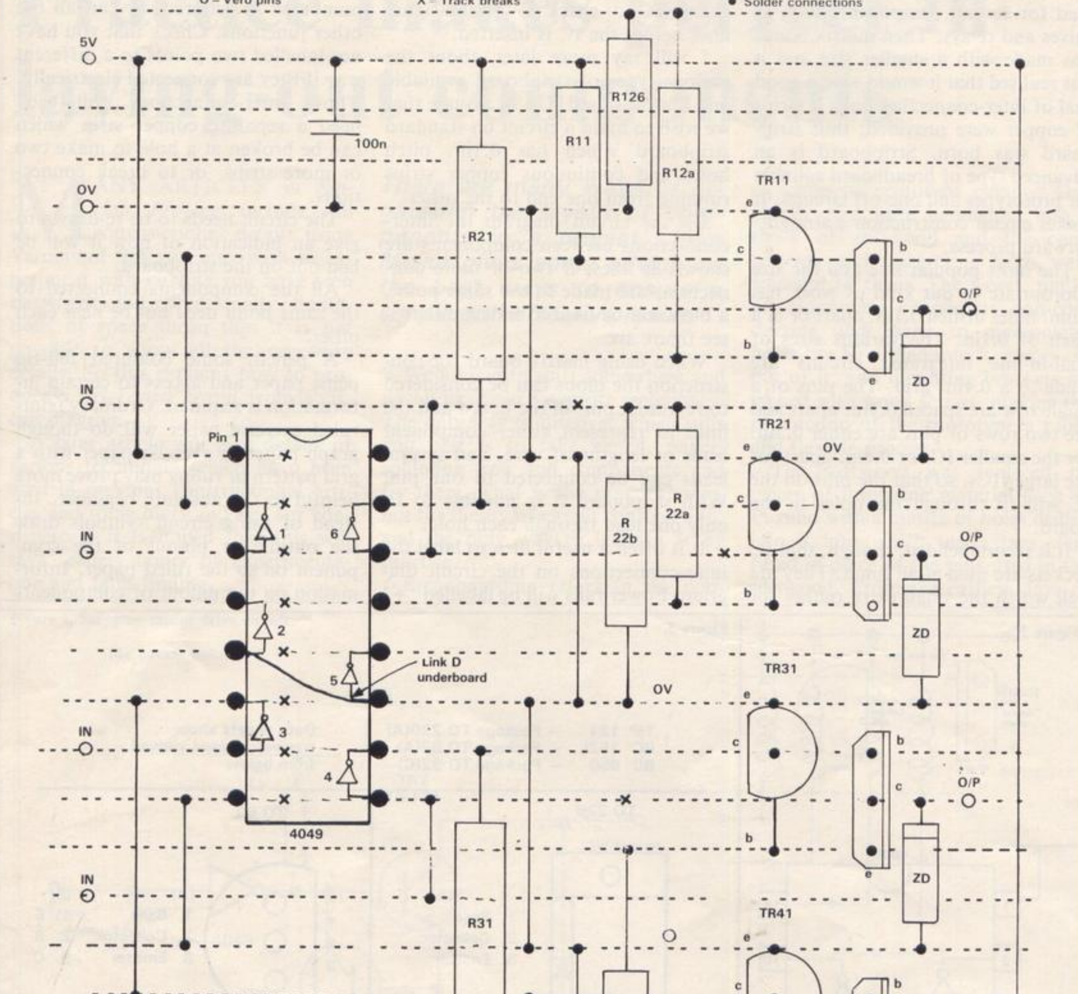


Figure 3.



CIRCUIT LAYOUT

Figure 5.



CIRCUIT LAYOUT

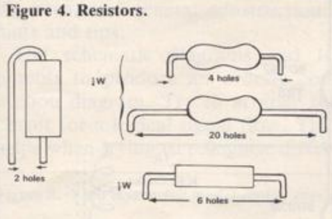
can be found in various places. Many component catalogues contain package details and pinout diagrams.

It is a worthwhile exercise to collect data on the components you will be using and to keep it handy for reference. Care and thought will need to go into the interpretation of some of the data and some of the diagrams are better re-drawn. An example is shown of a stepping motor driver circuit designed by Adrian Bailey—figure one.

Only one of the output circuits is shown on the circuit diagram although four of them are required. It uses two types of transistor. The first transistor TR1 is a BC182. There are various versions of most transistors. Those with the same number will perform the same function but they may be packaged in a different manner.

Once you have bought the component you will be able to compare it to the data. It may be in a metal can or a plastic package. It may have an additional letter after the number or even a different prefix. The type of

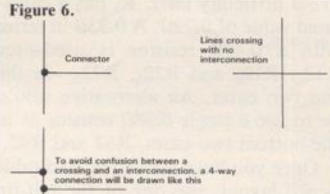
Figure 4. Resistors.



transistor I used had the number BC182L which looks exactly like the BC182 except that the three leads are in a different order, so be very careful.

The data sheets show transistors viewed either from the bottom as in the case of the BC182L or from the front as in the case of the TIP121 or even from the rear for some plastic power transistors. We need diagrams of all the components as viewed from the top, so draw them again on to a sheet of paper which you will keep with your data sheets and label it clearly View From Above. Integrated circuit data is already shown viewed

Figure 6.



from above and so may not need to be re-drawn—figures two and three.

When starting to draw the component layout do not be tempted to draw it life-size; draw it bigger, so that it is easier to see. You may need more than one sheet of paper but it is easy to line-up the separate sheets. The horizontal lines of the paper will represent the copper tracks running underneath the stripboard.

Choose a suitable grid spacing if you are using graph paper about 0.3in. or 10mm. apart. The top side of stripboard is the side on to which the components will be fitted; the leads will pass through the holes and be soldered to the strips on the underside.

The sketch you make will be a view from the top side as if you had X-ray vision and could see the copper strips through the board. The integrated circuits will look excessively large but later, with practice, you will be able to use a smaller grid.

Think about where the inputs and output to the board are to be and which components will be mounted off the board. Allow extra space for heatsinks and larger electrolytics. It may be helpful to do two drawings, one of them actual size so that you do not overcrowd the components by under-estimating the size of them.

Have some components and a piece of Veroboard on hand for sizing purposes — see figures 4a and 4b. Look at the horizontal connecting lines on the diagram and imagine them as copper tracks. The power lines will probably run from one side of the board to the other.

Then there are the input and output lines. It is possible to proceed in several ways. With discrete components it is easiest to start from one of the power lines and work up or down to the other one. With logic it is easiest to start from the input signals which may go to the board in parallel and to work through the various components to the output.

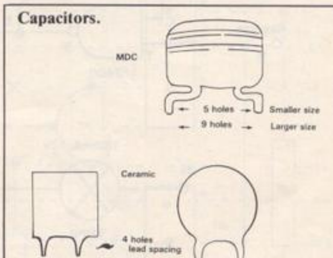
If we consider the hex buffer in the stepping-motor drive circuit we can see that there is a choice of using any four of the six buffers available on the device. When the circuit contains many gates scattered throughout the diagram it is a test of ingenuity to try to discover the most economical method of making the connections to the pins of the integrated circuits.

The signal may appear to travel from the left to the right of the circuit diagram while it may zigzag backwards and forwards on the circuit layout as it passes through the gates. The example shown uses the copper tracks on the board for all the horizontal links and tinned copper wire above the board for the vertical links. Thus the output of the first gate is taken vertically upwards to a horizontal track which connects it to the transistors.

The position of the components should be arranged so that as many connections as possible are made using the horizontal copper tracks, so reducing the number of links needed. An alternative to using only vertical links as shown would be to use insulated wire and route it around the IC to the transistors.

Similarly the input to gate four

Capacitors.



could be taken straight to the track connected to that pin. That reduces the number of soldered connections to be made. Inter-track links can also be made using insulated wire soldered and run along the underside of the

CIRCUIT LAYOUT

board. That may be necessary when there are many inter-connections. More will be said about a specific technique using a wiring tool in the accompanying article.

The components can be used to bridge across tracks. Note how one of the leads of the BC182L has been bent out to reach the track connected to the emitter of the TIP121. If the leads of your transistor are not long enough, use a short link as shown, labelled C. When the link is between adjacent tracks the bridge can be made underneath the board. When signal lines on the circuit diagram cross without being connected, see if it is possible to re-arrange the components so that they can be used to form the crossing or eliminate it.

The four TIP121 transistors have been mounted in a line so that they can be bolted to a heatsink if required. Positioning such as that or the mounting of pre-set resistors needs careful thought at this stage to avoid difficulty later. R_2 has a calculated value of 0.73Ω. A 0.33Ω in series with a 0.47Ω resistor is used—see $R12_a$, $R12_b$ and $R22_a$, $R22_b$—in the top two cases. An alternative would be to use a single 0.68Ω resistor as in the bottom two cases, R32 and R42.

Once you have arrived at a suitable pencil layout, use one of the felt-tip pens to mark all the places where the tracks will need to be cut. A vacant hole has to be left where the track will be cut, so check at that stage that the positions of the components will permit it.

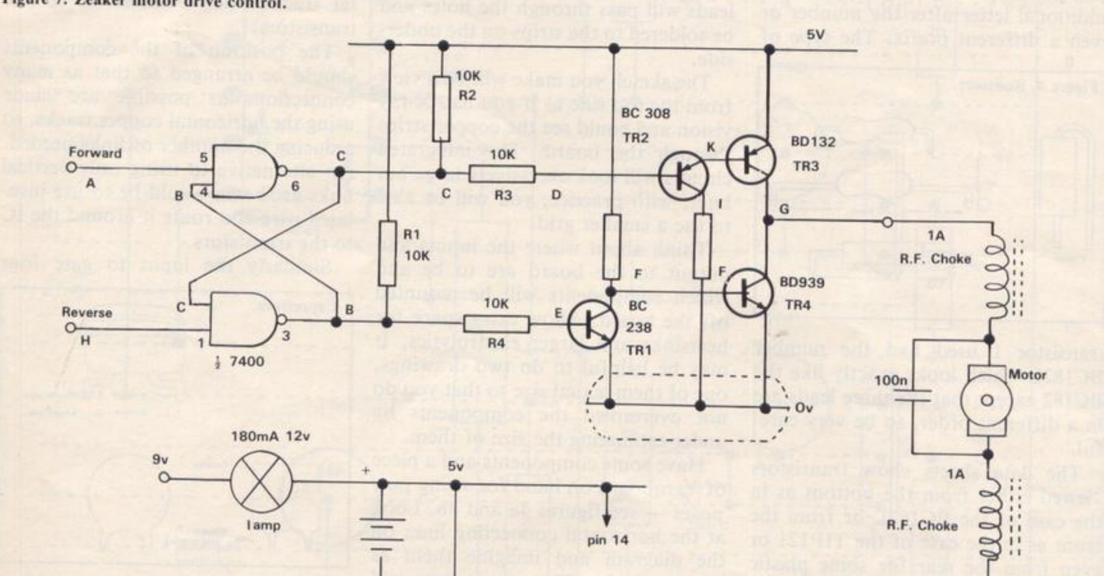
Use another colour to draw over all the links. Check the circuit as you do so to see whether two parts of the circuit are connected which should not be or vice versa. Next mark with a black pen the positions of all the IC pins, component leads and ends of the links; then, when you turn over the paper, you will be able to see where to cut the tracks after you have mounted your components.

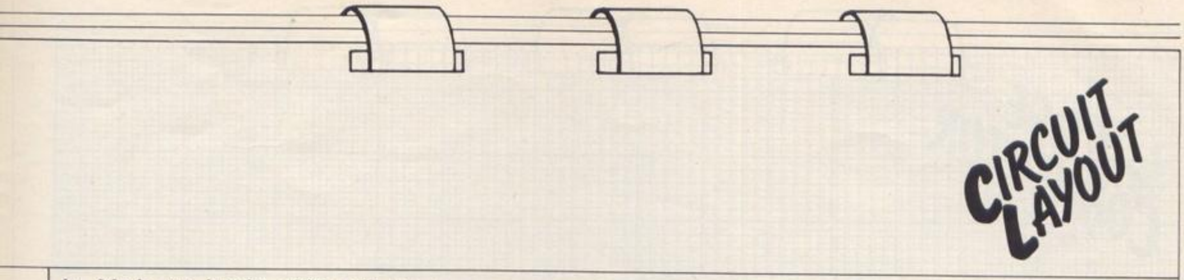
All you need to be able to recognise from the other side of the paper is the soldered connections and the breaks in the tracks, so use your strongest colours to mark them. If you are using underboard links, mark them in a strong colour on the upper side of your layout sketch. Most felt-tip pens will show through the paper well enough for you to be able to proceed confidently with the construction.

In *Sinclair Projects* the pinout diagrams of any unusual IC or components will be given and the pin numbers of ICs are always shown on the circuit diagrams to make it easier for the constructor to follow.

If you have a piece of board and some components to hand you can experiment by placing them. Figure four gives a guide to the placing of component leads in terms of numbers of holes. Use your drawing to check that all the correct connections have been made and to check that two points are not connected inadvertent-

Figure 7. Zeaker motor drive control.

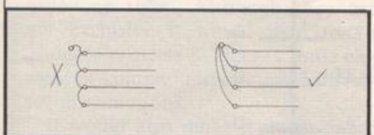




ly. Mark any breaks which will be required on the layout sketch. It is safest not to cut the tracks until after construction of the circuit. Sizes of components may mean that it is necessary to change the layout.

The second example—figure seven—is of a drive circuit for small model motors. Note that junctions D,E,K and I are easy to miss because they do not include a blob. That does not matter, because you will probably notice it as you start to do the layout and check the connections.

Two motor drive circuits can be built on a piece of Veroboard 25 holes



by 22 strips. Note that each motor drive circuit uses two of the four gates in the 7400 IC and also the power rails do not require duplication.

In the accompanying article we will consider bending component leads, wiring methods, including use of wiring pens, and general constructional hints and tips.

Use schematic diagrams and IC pinouts to produce an orderly connection diagram. Try to arrange the circuit for a logical signal flow. That helps when trying to recognise different sections of the circuit and makes the future design of printed circuit boards easier.

Circuit layout summary

Careful planning →
- Simpler wiring
- Minimum errors
- Easier trouble-shooting

ICs should point in the same direction wherever possible. That reduces the chance of putting one in the wrong way round and makes it easier to keep track of pin numbers.

Colour code the wiring—red for positive supply and black for negative supply (OV).

Do not daisy-chain power supply connections. Run a separate wire from the positive or OV supply to each power bus.

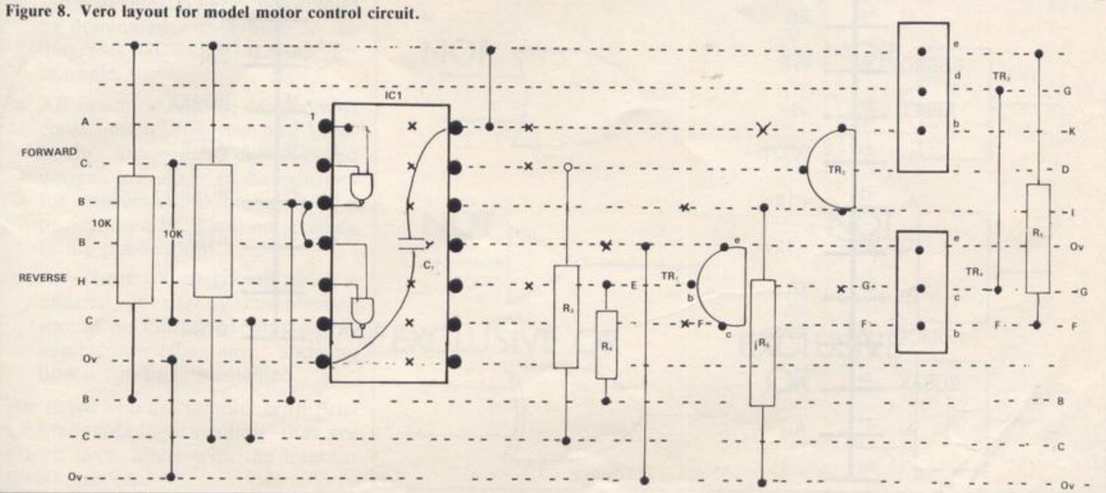
Keep all connecting leads short and route them around ICs so that defective components can be replaced. Mount capacitors so that their values are readable. Insert resistors with their colour codes reading from left to right or top to bottom. Keep component leads short to avoid shorting and inductance.

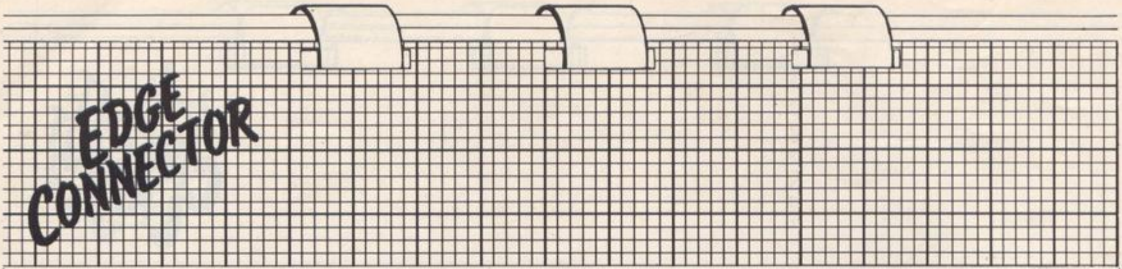
For decoupling, each circuit board should have its power rails decoupled by a 25 to 100μF electrolytic capacitor in parallel with a 0.1μF capacitor. If the 0.1μF capacitor has 1in. leads the bypassing is effective to 2.5MHz. If the 0.1μF capacitor has ¼in. leads effective bypassing is extended to 5MHz.

TTC and CMOS circuits should have one 0.1μF or 0.01μF capacitor between positive and negative next to every IC, or at least every other IC. Higher-frequency circuits such as ECL or Schottky TTL need 100 to 1,000pF capacitors in addition to the 0.1μF and 0.01μF capacitors.

Build and test one section of a circuit at a time. Check connections to each IC, pin by pin, twice. Remove IC, apply power and check for correct polarity in the proper place. Always switch off before removing or inserting an IC. Do not remove ICs with your fingers; you are liable to have a perforated thumb and bent IC leads. Use a small screwdriver or IC remover to ease them out.

Figure 8. Vero layout for model motor control circuit.





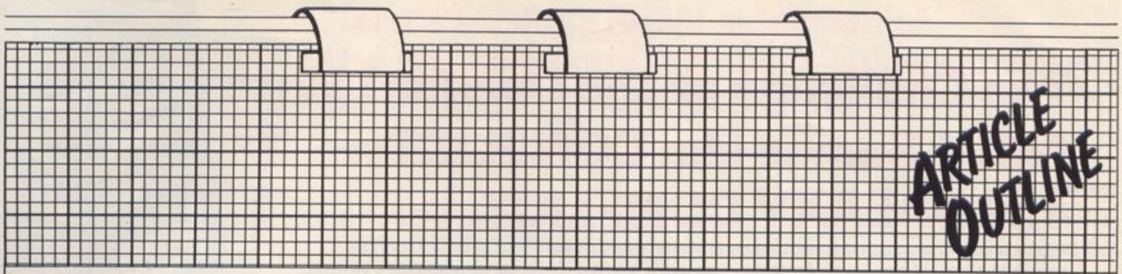
Edge Connector signal allocation

SPECTRUM

Pin	BOTTOM (Side B)	TOP (Side A)
1	A_{14}	A_{15}
2	A_{12}	A_{13}
3	5v	D_7
	9v	
	Slot	Slot
	0v	D_0
7	0v	D_1
8	CK	D_2
9	A_0	D_6
10	A_1	D_5
11	A_2	D_3
12	A_3	D_4
13	$\overline{IORQGE}$	$\overline{INT}$
14	0v	$\overline{NMI}$
15	Video	$\overline{HALT}$
16	Y	$\overline{MEMRQ}$
17	V	$\overline{IOREQ}$
18	U	$\overline{RD}$
19	$\overline{BUSRQ}$	$\overline{WR}$
20	$\overline{RESET}$	−5v
21	A_7	$\overline{WAIT}$
22	A_6	+12v
23	A_5	−12v
24	A_4	$\overline{MI}$
25	$\overline{ROMCS}$	$\overline{RFSH}$
26	$\overline{BUSAK}$	A_8
27	A_9	A_{10}
28	A_{11}	

ZX-81

Pin	BOTTOM (Side B)	TOP (Side A)
1	5v	D_7
2	9v	RAM CS
3	Slot	Slot
4	0v	D_0
5	0v	D_1
6	$\overline{\emptyset}$	D_2
7	A_0	D_6
8	A_1	D_5
9	A_2	D_3
10	A_3	D_4
11	A_{15}	$\overline{INT}$
12	A_{14}	$\overline{NMI}$
13	A_{13}	$\overline{HALT}$
14	A_{12}	$\overline{MREQ}$
15	A_{11}	$\overline{IORQ}$
16	A_{10}	$\overline{RD}$
17	A_9	$\overline{WR}$
18	A_8	$\overline{BUSAK}$
19	A_7	$\overline{WAIT}$
20	A_6	$\overline{BUSRQ}$
21	A_5	$\overline{RESET}$
22	A_4	$\overline{MI}$
23	ROMCS	RFSH



The good author's guide to explaining projects

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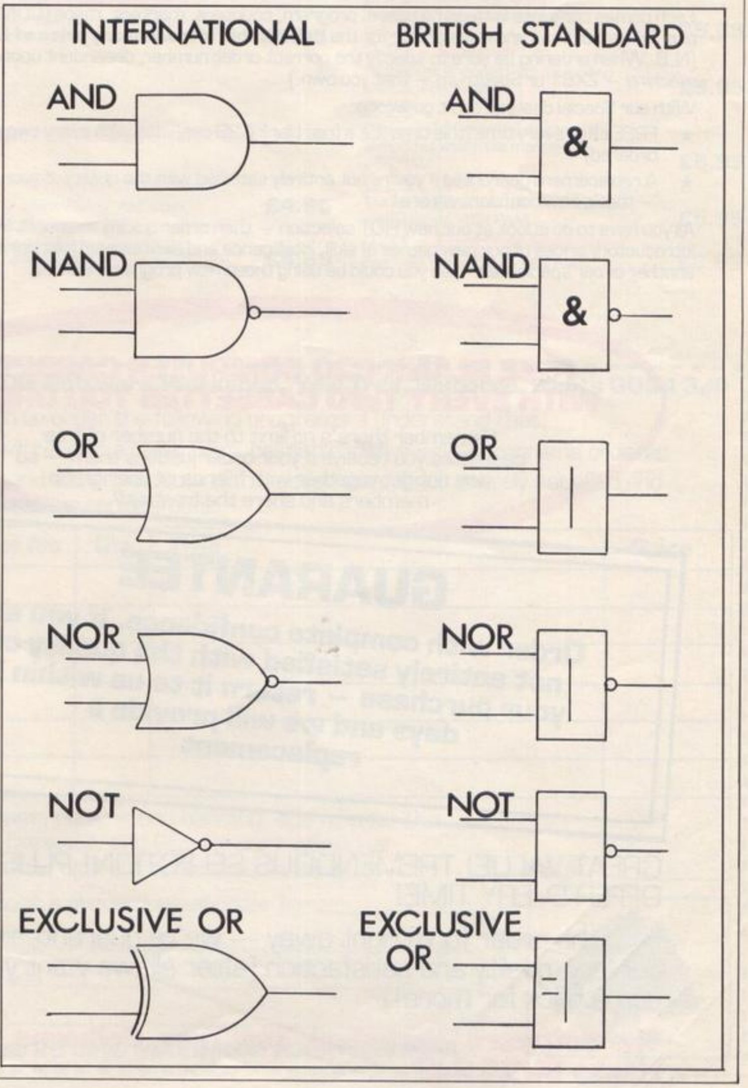
It would also make it much easier for us to publish the articles without errors as there would be less chance of confusion about meanings. The main points to note are:

- All manuscripts should be typed with double-line spacing.
- Logic symbols should follow international standards.
- Circuit symbols should follow international standards.
- Circuit diagrams should have the values of the components shown, not a reference to a component table.
- Parts of integrated circuits should be designated with a note on the diagrams—IC5 - 74LS14, for example.
- All circuits should be designed for construction using standard Veroboard. Any printed circuit board designs are likely to be returned for conversion. Submission of a project on a PCB will not exclude future publication.
- Any constructional detail which is unusual or slightly complicated should be illustrated with simple hand-drawn diagrams, showing how it can be implemented.

For those who are familiar with British Standards logic symbols, they are shown here, along with the international symbols.



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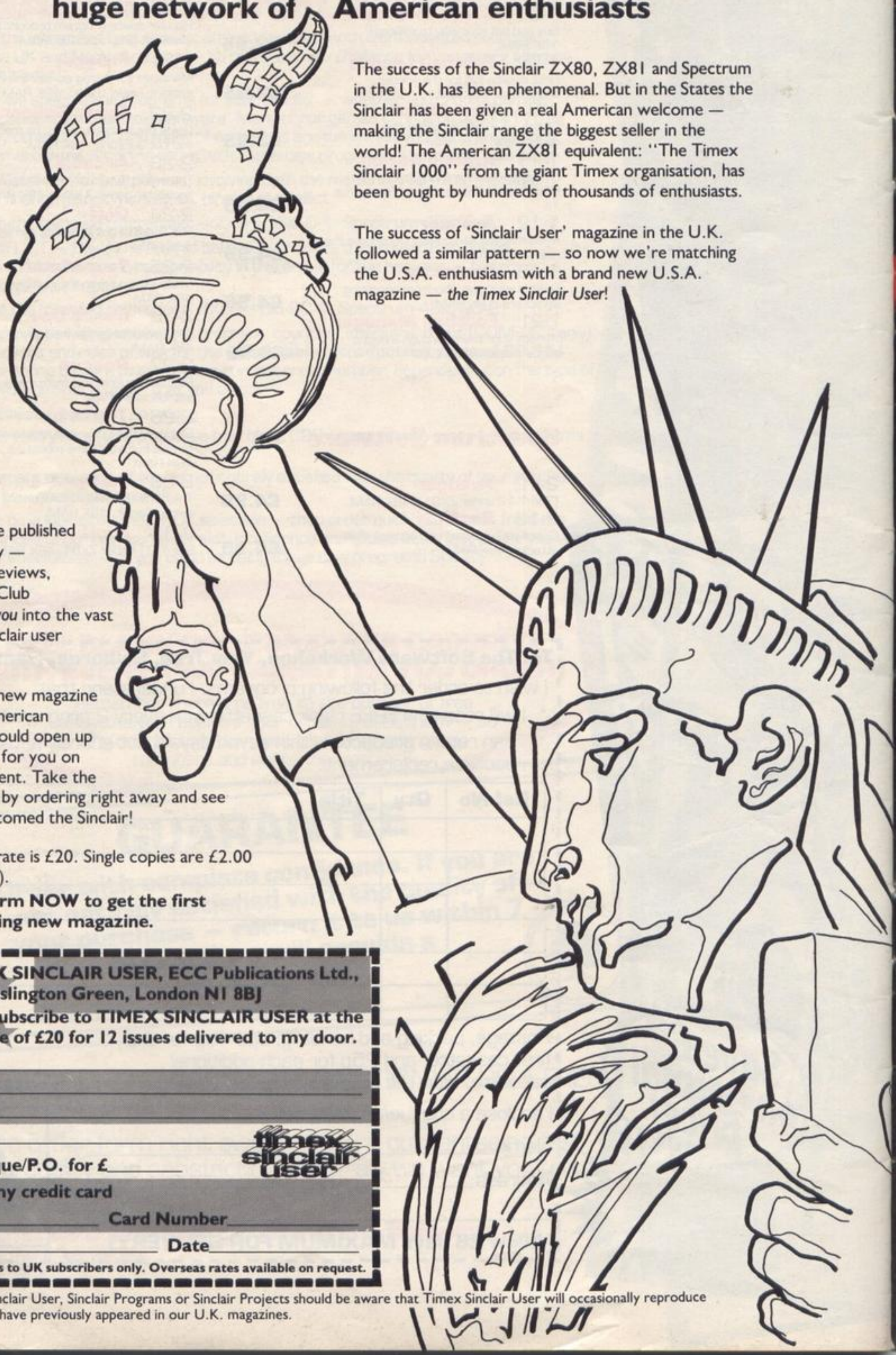

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